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A MONOGRAPH OF THE RECENT CEPHALOPODA

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A MONOGRAPH OF THE RECENT CEPHALOPODA

BASED ON THE COLLECTIONS IN THE
BRITISH MUSEUM (NATURAL HISTORY)

PART I
OCTOPODINAE

By

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OF ZOOLOGY

LONDON:
PRINTED BY ORDER OF THE TRUSTEES OF THE
BRITISH MUSEUM

SOLD AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, S.W.7
AND BY
B. QUARITCH, LTD.; DULAU & CO., LTD.; THE OXFORD UNIVERSITY
PRESS; AND WHELDON & WESLEY, LTD., LONDON; ALSO BY
OLIVER & BOYD, EDINBURGH

1929

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Issued 27th July, 1929]

.B8
V.1
447 60

PRINTED IN GREAT BRITAIN BY
RICHARD CLAY & SONS, LIMITED,
BUNGAY, SUFFOLK.

PREFACE

THIS volume is the first instalment of a systematic review of recent Cephalopoda, and deals with the large subfamily Octopodinæ, containing forms to which the popular name "Octopus" is applied. The collection of these animals in the Zoological Department is a rich one, containing the types of species described by Dr. J. E. Gray and Dr. W. E. Hoyle ("*Challenger*" collection) and other specimens of historical importance. In addition, the author has visited several of the larger continental museums, and other museums have generously allowed him to borrow valuable material or have supplied photographs of types which could not be lent. For these and similar courtesies the thanks of this Department are due to the following institutions and individuals:—Zoologisches Museum (Berlin), Indian Museum (Calcutta), Royal Scottish Museum (Edinburgh), Senckenbergisches Institut (Frankfurt a.M.), University Museums (Göttingen and Jena), 's Rijk's Museum (Leiden), University Museum (Leipzig), Musée d'Histoire Naturelle (Paris), Royal Museum (Stockholm), Musée Zoologique de l'Université and de la Ville (Strasbourg), United States National Museum (Washington); Dr. P. Bartsch, Dr. L. Blöte, Dr. S. S. Berry, Prof. G. Grimpe, Dr. F. Haas, Dr. H. Hoffmann, Prof. L. Joubin, Miss A. L. Massy, Prof. N. Odhner, Dr. B. Prashad, Dr. B. Rensch, Mr. J. R. le B. Tomlin, and Mr. R. Winckworth.

It has long been recognised that the species of Octopodinæ are particularly difficult to define. Their external characters are often subject to alteration, as, for example, by the action of preservatives, making it hard to obtain series of specimens in comparable condition. Moreover, as in many other groups of animals, the description of "new species" has gone on without any critical revision of the species supposed to be already "known." Much of the obscurity that has thus arisen still defies, and will probably always defy, elucidation. Meanwhile it is hoped that the revision here attempted will facilitate future study of the group. The author has indicated on pp. 1, 4 and 31 some problems relating to evolution and adaptation in this group of animals, as they present themselves to the systematist.

W. T. CALMAN,
Keeper of Zoology.

British Museum (Natural History),
April 22, 1929.

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A MONOGRAPH OF THE RECENT CEPHALOPODA

I. INTRODUCTION.

(*a*) Scope of the Work.

The Octopodinae, which form the subject of the first part of this monograph, are commonly known as "devilfish" or "octopods." They are a subfamily of the eight-armed Cephalopoda and include those forms which have been usually placed in the genus *Octopus*, such as the Common Octopus of the East Atlantic and Mediterranean. These animals are exclusively marine, and, like the Amphineura and Scaphopoda among other Molluscs, are not found in fresh or even brackish waters. The majority of the species live in depths of less than 100 fathoms, and are found in all the tropical and temperate seas of the world. They are not found in high latitudes, or in water of low temperature. In size they range from giant forms like *Octopus apollyon*, which spans nearly 28 feet with its arms, to small species which span barely two inches. As far as it is possible to speak of their habits and disposition they may be described as carnivorous, solitary and aggressive.

The Octopodinae form the largest division of the Order Octopoda, and the species placed in this subfamily easily outnumber those in the other groups. As far as the divergence of species is concerned they are in a far more active evolutionary state than (*e.g.*) the Cirrata and Eledonellidae. Morphologically considered, however, the group is rather featureless. Most of the species are of an unspecialized type and differ from one another in trivial and apparently insignificant details.

The work of which this volume is the first instalment has for its object a complete study of the morphology and evolution of the Class Cephalopoda, and the second volume will deal with the more interesting and specialized Bathypolypodinae, Argonautidae, etc. As a prelude to this study, however, it is necessary to deal with the classification of the less specialized Octopodinae, primarily with the object of seeing if in that large and confused assemblage of species there are any well-marked morphological tendencies which might cast some light on the evolution of the more specialized forms. The present work deals with inevitable questions of specific identity and variation, synonymy, etc., but an attempt has been made in Section VI and at various points in the systematic part to direct attention to wider and more interesting topics. The web, for example, is highly differentiated (see p. 7) in size and shape. It is possible that it may be of use either in brooding or in locomotion, but we do not know if the various characteristic shapes which it assumes are related to differences of function or due to non-adaptive tendencies. Nevertheless its modification is a highly distinctive

feature in Octopod evolution. The first signs of modification are to be found in the Octopodinae. Insignificant in forms like *Octopus defilippi* the web begins to increase in size in *Octopus vulgaris*. It is very deep in *Hapalochlaena* and *Bathypolypus* and finally in the Cirrata it forms a large bell-like structure conferring on the animal a medusiform appearance.

There is no doubt that in the structure of the Octopodinae are to be seen many tendencies which are more fully realised in the deep-water Bathypolypodinae and Cirrata. The shortening of the arms, the deepening of the web, the reduction of the ink sac and gills, the narrowing of the pallial aperture are features which occur in the Octopodinae and find their maximum expression in the Cirrata.* This is perhaps the fact of most general interest which emerges from the study of these animals, and its interest is heightened, if we recollect that these tendencies are seen in animals which are principally of littoral habitat. This subject will be more fully discussed in the second volume. For the present it is enough to say that the Cirrata and the true "Octopods" probably diverged from one another at a comparatively early stage in Octopod evolution. The special features in which certain of the Octopodinae tend to resemble their deep-water relatives are more likely to be due to adaptation to certain factors common to the abyssal environment and certain kinds of shallow-water habitats ("epharmonic convergence") or to some orthogenetic process than to close relationship. (See especially Robson 1926*a*, p. 1356, and Kemp, 1917.)

This work is primarily a catalogue of the specimens of Octopodinae in the Zoological Department of the British Museum. It contains in addition a survey of the group as a whole and an account of the described species, together with a sketch of their morphology and a survey of variation in the Common Octopus. Information as to the specimens in certain European museums is included. There is no attempt to deal with the physiology of these animals or to give a complete account of their anatomy and development. Certain anatomical features of systematic and bionomic importance are, however, described in detail and a summary of the habits is given. The characteristic features of the young are described; but, as it was not possible to undertake a special study of the postembryonic stages, such young specimens as have been recorded by other workers (*e.g.* Hoyle) are not discussed except in certain special cases. Previous records in which no specific name is used ("*Octopus* sp.") are similarly ignored.

(*b*) Systematic Position of the Subfamily.

The Octopodinae together with the Eledoninae and Bathypolypodinae form the family Octopodidae. The systematic position of this family is as follows:—

Order OCTOPODA, Leach.

Suborder 1. CIRRATA, Grimpe (*Cirroteuthis*, *Opisthoteuthis*, etc.).
,, 2. PALAEOCTOPODA, Naef.
,, 3. INCIRRATA, Grimpe.

* The question as to which of the special characters of the Cirrata are archaic and which are the result of specialization will be considered in the next volume.

Family 1. Eledonellidae, Sasaki.
„ 2. Amphitretidae, Hoyle.
„ 3. Octopodidae, Orbigny.

Subfamily 1. Eledoninae, Grimpe. Ink sac present: eggs large: suckers uniserial.
„ 2. Octopodinae, Grimpe. Ink sac present: eggs usually small: suckers biserial.
„ 3. Bathypolypodinae, Robson. Ink sac absent: eggs (?): suckers biserial.

Family 4. Argonautidae, Naef.

On p. 40 is given a table of the genera at present recognized in the Octopodinae.

(*c*) Classification.

Our knowledge of the broad outline of Octopod classification is due to Naef and Grimpe and is eminently satisfactory. It is far otherwise, however, with the classification of the subordinate group treated in this volume. During the last fifty years no comprehensive study of this subfamily has been attempted, although it contains some of the most remarkable and characteristic of littoral animals. Students have confined themselves to the description of species and, as a result, the Octopodinae have become an unwieldy mass of species with few subdivisions. Through this mass the systematist gropes his way in hopeless confusion, and may be easily excused for shirking the task of reducing it to order; for it presents special difficulties of more than one kind. The species of Decapod Cephalopods are not as a rule difficult to distinguish. The Octopodinae, on the other hand, confront the systematist with difficulties not unlike those encountered, for example, by the student of Corals and Hydroids.

These difficulties are of four kinds. Three of them are largely adventitious and the fourth seems to be rooted in the constitution of the group.

I. The characteristic sculpture of the skin seems to be easily effaced, altered by preservation and subject to marked *post-mortem* changes. The cutaneous warts and tubercles, which are a marked feature in many forms, evidently contract after death and still more under the influence of preservatives. The strong muscular system devoid of any rigid internal support is the seat of distortion at and after death, which often obscures the natural shape, especially of the visceral sac and the head. The liability of the delicate extremities of the arms to breakage and consumption by the animal itself (and possibly by its partners) often renders their relative length difficult to ascertain. Colour is changeable even in life and liable to rapid alteration after death.

II. These animals, owing to their activity, solitary habits and secretive mode of life are rarely caught in large numbers. The amount of material available for the study of a single species is generally limited, so that the amount of variation of a given species is often entirely unknown. The difficulties enumerated in I.–II. might of course be largely obviated, if freshly-caught and specially-preserved specimens were

used. A large part of the work of systematic revision is concerned, however, with the indifferently-preserved type-specimens and other historical material. A large supply of well-preserved specimens and observations on the living animal would materially assist us in this work; but the accumulation of such material is very difficult and can only be accomplished very slowly.

III. These animals require very exact and exhaustive description, more particularly of the parts which are not affected by lesions and *post-mortem* changes. The earlier students, however, confined themselves to the description of more or less valueless characters; measurements were often given without a precise definition of the points between which they were taken; no attempt was made to observe a uniform system of diagnosis and useful systematic characters, such as the proportion of the web, size of the suckers, etc., were often summarily expressed in general terms. It is desirable therefore to exercise very great caution in ascribing to a species the characters of all the specimens referred to it by previous workers.

IV. A more fundamental difficulty is indicated by Appellöf (1898, p. 570), who states that "in dieser Gattung eine Artbildung noch vor sich geht, aus welcher bis jetzt nur wenige verhältnissmässig charakteristische und konstante Arten hervorgegangen sind." Wülker (1910, p. 8) expresses a similar opinion after a study of the Japanese forms. These authors seem to have been led to this view by the fact that in this group there is a very great amount of individual variation, so that each individual constitutes a separate diagnostic problem. As a rule the limits between species are extremely indistinct, and intermediate forms are very common. One does not encounter even in those forms (e.g. *Octopus rugosus*, *vulgaris*, *macropus*) that are numerically well-represented in museum collections the relatively homogeneous groups which are sometimes found, *e.g.* in Gastropods. In the Octopods this difficulty is no doubt augmented by the numerical poverty of the material. A few individuals collected at points remote from one another cannot be expected to be completely identical. For this reason we should not exaggerate the genetic diversity of Octopod populations. But among the populations found in more circumscribed areas species are often very ill-defined, and even the individuals taken in a single haul may be conspicuously diverse. Some allowance must be made for the fact that preservation and the circumstances of death alter the colour, sculpture and shape of these animals. Very probably in life the specific characters are more easily distinguished, and colour, shape and sculpture are more constant. The difficulty, however, remains even after those characters which are modified by accident are disregarded. The cause of this diversity is hard to discover. One explanation may be that the group is, as Appellöf suggested, in a very active evolutionary state with numerous new mutations arising and spreading through the general population. Alternatively there may be little isolation and such new mutations as arise may be rapidly and effectively diffused. These animals seem to deposit their eggs inshore, where they are fixed down to rocks, leaves, débris, etc., but they probably pass a considerable time offshore in a pelagic condition when young. The special powers of adhesion may facilitate their dispersal by coastal traffic and floating débris.

It is clear that intensive studies on the variation of single species are still much needed, and that such investigations should be carried out on the living animal.

(*d*) Historical.

The special study of the Octopoda may be said to date from Aristotle, who devoted much attention to these animals and described with a wealth of detail and great accuracy the habits and appearance of the Mediterranean forms. In the long interval between Aristotle's work and the first modern comprehensive study of the group there are a certain number of good descriptions of single forms such as that of Jonston (1657) and Kölreuter (1761). The writings of delle Chiaje, Lamarck's "Mémoire sur les genres de la Sèche, du Calmar et du Poulpe" (1799) and Cuvier's "Mémoire sur les Céphalopodes" (1817*b*) are notable contributions on a limited scale. H. de Blainville (1826) made the first attempt to treat the group comprehensively. But Orbigny's masterpiece, the "Histoire Naturelle des Céphalopodes acétabulifères," of which the first section of the text was published in 1835, is actually the first critical and exhaustive systematic treatment of the group. In it Orbigny attempted to formulate subdivisions of *Octopus* founded on the length of the arms. In his "Catalogue of the [Cephalopoda Antepedia] in the Collection of the British Museum" J. E. Gray (1849) made another attempt to subdivide the group by using the size and arrangement of the suckers and the character of the epidermis. He recognized a family (Octopidae) containing *Octopus*, *Cistopus*, *Pinnotopus* [sic], *Eledone* and *Cirroteuthis*. Tryon (1879) recognized seven genera and utilized a combination of the methods of Gray and Orbigny for subdividing the genus *Octopus*. Hoyle, Appellöf, Brock, Verrill and Joubin made notable contributions to the study of the group, but their work was mainly of a detailed kind and they made no attempt to introduce order into the growing mass of species. Appellöf's discovery of the absence of the ink sac in a deep-sea form * (*Octopus piscatorum*) (1892, p. 5) was of considerable value and formed the basis of a subdivision of the group made by Grimpe (1921). In the same year the latter produced a more fundamental scheme involving the recognition of ten genera. In 1928 I proposed the elevation of the two abyssal genera *Bathypolypus* and *Benthoctopus* with the new genus *Grimpella* to the status of a subfamily. Since the beginning of the present century valuable faunistic work has been published by Joubin, Massy, Wülker, Berry and Sasaki. Naef's monograph on the Cephalopoda of the Gulf of Naples (1921–8) contains much valuable matter on the structure and morphology of the group.

* It had previously been shown to be absent in *O. arcticus*, but this was regarded as an exceptional case.

II. STRUCTURE.

The external and internal structure of these animals is fairly well known. There is, however, no exhaustive monograph on any member of the subfamily, and for a detailed modern account of an Octopod recourse must be had to Isgrove's monograph on *Eledone*. Cuvier and Orbigny both published rather summary descriptions of *Octopus*, and there have been numerous papers on individual organ-systems. Meyer's monograph (1913) on *Sepia* and *Octopus* is extremely useful; but it does not treat *Octopus* with the fullness of detail to be attained in a work devoted exclusively to one genus. In recent years Grimpe (1913, circulatory system), Marchand (1907, 1913 male genitalia, spermatophores), Robson (1925, radula) and others have described individual systems in some detail, and Naef (1923) has discussed the general morphology of the group. The following description is not an exhaustive account of the anatomy; it contains a special description of those parts which are important in classification together with fresh information on several structures and organs. In the second part of this work an account of the morphology of the family Octopididae will be given, in which the general architecture of the body and the modification of its parts will be discussed. The following account of the anatomy of the Octopodinae contains only such matter as is of importance in the classification of this subfamily. Attention is drawn to the remarks on terminology.

External Anatomy. The body of an Octopus is formed of two main parts, the body proper containing the viscera, and the head ("capito-pedal mass") the edges of which are drawn out into the characteristic eight arms. In this work the word "body" is used for the visceral mass and the mantle which invests it, and "head" for the head-foot. In the past no standard orientation of the Cephalopod body has been adopted; authors have variously adopted an orientation based on morphological principles or one dependent on the posture assumed by the animal when swimming (cf. Hoyle, 1886, p. 53). Lankester (1884, p. 664) gave a clear explanation of the orientation of the Cephalopod body according to morphological principles. The plantar surface of the head-foot was defined as ventral and the pallial cavity as posterior. It would be preferable to retain this scheme of orientation and to use the terms "ventral" and "dorsal," "anterior" and "posterior" in describing the Octopod body exactly as they are applied to an Amphineuran or Gastropod. Nevertheless the orientation based on the posture adopted when swimming horizontally, *i.e.* having the mantle cavity below, has become so general that I am disinclined to suggest that the morphological orientation should be generally adopted. I have accordingly treated the morphologically posterior surface as "ventral" and the morphologically anterior surface as "dorsal."

The head is intimately fused with the mantle in the anterior dorsal (nuchal) region, and the ventral flap of the mantle is joined to the visceral

mass by the median pallial adductor muscle. The visceral mass, however, is not connected with the dorsal portion of the mantle behind the nuchal fusion. The connection between visceral mass and mantle is limited to (*a*) the posterior region, (*b*) the nuchal area and (*c*) the median ventral line, and is in strong contrast to the architecture of the Decapod body. In *Macroctopus* (Robson, 1928*d*) the ventral union of the mantle and visceral sac attains its maximum. It should be pointed out that *Sepiola* (nuchal union of head and mantle), *Idiosepius*, *Lepidoteuthis* and the Sepiolidae (median pallial adductor) among the Decapoda resemble the Octopoda in isolated features of the attachment of the mantle to the viscera. The significance of these various modifications will be discussed in Vol. II.

The body of the Octopodinae is usually saccular and broadly oval, but it exhibits on the one hand a tendency to become globular (e.g. *O. tonganus*) and on the other to attain a narrow squid-like form (*Octopus teuthoides*, *fusiformis*, *Macroctopus*, *Macrochlaena*). The sexes tend to differ in the shape of the body (cf. p. 15). The circumference of the body sometimes exhibits a continuous tegumentary ridge. The genus *Pinnoctopus*, according to the only available account, has this ridge developed as lateral fins like those of a *Sepia*. The status of this form is, however, questionable (see p. 184), and, as the ridge is found sporadically in species usually devoid of it (*Octopus rugosus*, *Scaeurgus unicirrus*, etc.), I am inclined to regard it as devoid of direct morphological interest.*

The head is usually well defined by praeocular and postocular constrictions; but it is sometimes merged very closely with the body. The integument of the head is continued forwards as a membranous expansion, the web, which is stretched between the arms. In the Octopodinae this structure, which in the Cirrata is often extensive and confers on the animal a medusiform appearance, usually attains a depth of about 25% of the longest arm; but in *Hapalochlaena*, *Pteroctopus*, etc., it may be as much as 40–50% of the arms. In others, again, it is very shallow (*Octopus niveus*, *defilippi*). I have already pointed out (1928*a*, p. 642) that this organ, though variable, is of considerable systematic value. (*a*) The *depth*, *i.e.* the length of the interbrachial sectors measured from the mouth to the circumference of the web (fig. 1) is rather constant within the various species. (*b*) The *form of the web* is very varied. To appreciate this, reference should be made to fig. 1, where the four most typical forms of web are illustrated. The various interbrachial sectors are collectively arranged according to one of the following plans :—

A. All sectors equal (radial).
B. Sectors bilaterally symmetrical (bilateral).
   (i) Depth of the sectors diminishing dorso-ventrally.
   (ii) Depth diminishing ventro-dorsally.
   (iii) Lateral sectors larger than sagittal.

I have suggested that a formula analogous to the arm-formula may be used for denoting the various types of web. Each sector of one side is lettered as in fig. 1, and the form of web is denoted by a particular series of the letters placed in the order of size of the sectors which they represent. Thus the web shown in fig. 1 (A) would be represented as

* See, however, Naef (1923, p. 675).

"A = B = C = D = E"; that shown in fig. 1 (B) would be A.B.C.D.E.; and fig. 1 (D) would represent the formula C.D.B.E.A. This type of formula is largely used in this work. (*c*) The web also differs a good deal in the extent to which it is prolonged up the sides of the arms as lateral or brachial membranes.

In the genus *Cistopus* and, as far as I know, in no other genus, the oral surface of the interbrachial sectors of the web is perforated by

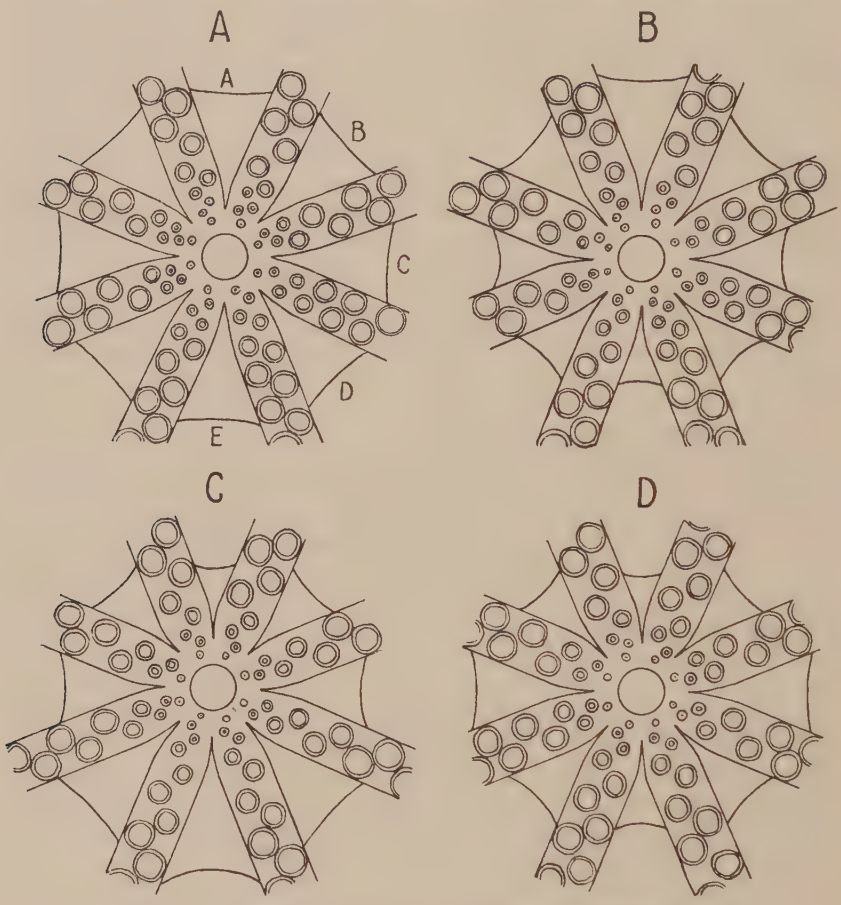

Fig. 1.—Types of Web in the Octopodinae. (Diagrammatic.)

a pore, one such pore occurring in each sector. The pores lead into oblong subcutaneous pouches or crypts, which are disposed with their long axis parallel to the arms and with the apertures at their inner extremity. The function of these pouches, which are of simple construction, is unknown*; an examination by means of sections would be of interest.

The eight arms are usually stout at the base and taper towards the extremities. In certain forms (e.g. *Octopus filosus*) they are very attenuated and filiform. This condition may, however, be due to

* They are not homologous with the "buccal pits" of *Loligo;* but, though they are present in both sexes, they may possibly be used in the female for the reception of the spermatophores.

accident. The arms are muscular and undergo characteristic *post-mortem* contraction, which in some species is of diagnostic value. They are paired and bilaterally disposed on each side of the (morphologically) antero-posterior axis. It is customary to number each pair (the members of which, except those of the third pair in males, are equal), beginning from those on each side of the median dorsal line, and each arm can be designated by the number of its pair and the letter L or R for "left" or "right." Thus 2L means the second arm on the left. The pairs are not always equal in size, and it has long been customary to use the relative size of the pairs for systematic purposes. The order of size is expressed by a formula in which the numbers of the pairs are placed in their order of length. Thus 1234 means that the first pair is the longest, the second pair next in order and so on. This feature is of dubious systematic value, as the arms are often damaged and subject to regeneration. It is only used in this work with very considerable reserve. The total length of the arms varies considerably from over 90% of the total length of the animal to under 50%. The arms are relatively shorter and less differentiated in young animals.

The modification of one or more of the arms to form a copulatory organ is discussed on p. 16. The ventral surface of the arms is flat and furnished with two rows of suckers. The latter are sessile, *i.e.* not placed on pedicels as in the Decapoda, and are devoid of a chitinous armature. They are usually arranged in pairs, except for the first three or four suckers which are commonly uniserial, and they are counted from the mouth outwards. The first (adoral) suckers of the arms are occasionally found somewhat separated from the second suckers and forming a close peribuccal ring (cf. Robson, 1926, p. 166). The significance and taxonomic value of this arrangement is obscure. The suckers are not as a rule equal in size. The diameter of the 12th pair usually is largest and the suckers decrease in diameter distally and proximally. In a good many species the lateral arms (more rarely all the arms) of the male bear specially and abruptly enlarged suckers at this point. These enlarged suckers are sometimes found in old females. It is usually assumed that these enlarged suckers are of service in copulation and are thus comparable to the "apparatus copulator" (fixator) of certain Decapoda (Naef, 1923, pp. 580, 604, etc.; Grimpe, 1925, p. 79). But it is by no means certain that the suckers are thus used, as the male apparently does not grasp the female in such a way as to make the adoral suckers specially important. It is a curious fact that some Octopoda which have a very large copulatory organ have no specially enlarged suckers (*Bathypolypus*, etc.).

The diameter is the only character of the suckers which is used for systematic purposes in this work. I suspect that the fine structure of the cups may be of considerable value, but this matter is in need of special investigation.

On the posterior surface of the mantle is seen the pallial aperture, a transverse slit from which the funnel projects. This slit is usually wide and extends on each side almost as far as the eyes. In the subfamily there is a tendency for it to become narrow and confined to the middle line. In *Hapalochlaena* and *Pteroctopus* it is scarcely wider than the base of the funnel, and thus foreshadows the complete closure of the

aperture seen in certain Cirrata. I have suggested a rough method of indicating the degree of closure (1926*a*, p. 1334) by designating the widely open stage as C, the condition in which the aperture extends on each side halfway to the eyes from the median line as B and the stage at which the aperture is confined to the base of the funnel as A.

The funnel is a muscular organ formed from the tissues of the head-foot. It can be divided into three regions: (*a*) The most anterior and exposed part is in the form of a tube with a more or less circular aperture. There is no siphuncular groove formed to receive it in the head nor any internal valve, such as occur in the Decapoda. It is free from the tissues of the head for about one-half to one-third of the total length of the whole organ; but in some instances it is entirely fused to the head. (*b*) The basal portion is expanded just inside the mantle aperture, and its ventral edge is reflected to form the cephalic component of the "locking apparatus" (*infra*). This flanged or reflected portion is either continuous from side to side or resolved into right and left lateral elements by a deep median incision. (*c*) The posterior extremities of the funnel

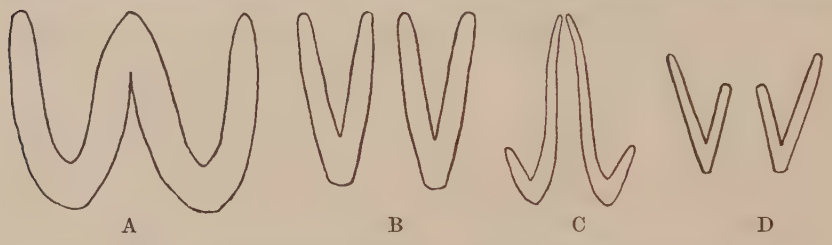

Fig. 2.—Outline drawings of various types of funnel-organ.
A, W-type; B, VV-type; C, *Octopus tenuipulvinus*; D, *Octopus macropus*, var. *minor*. (C and D after Sasaki).

are continued into the siphonal depressor muscles which form a pair of conspicuous ridges on each side of the anus. On each side of the funnel in some species are found conspicuous pouches. Inside the cavity of the funnel on its dorsal wall is the characteristic "funnel organ" ("Müller's organ"), a superficial patch of glandular tissue which secretes a lubricant, no doubt for promoting the expulsion of débris of various kinds which might otherwise obstruct the bore of the funnel. This organ is composed of four short oblong sections arranged as a W, M or VV-shaped patch. It is sometimes absent (*e.g.* in *Macroctopus*); but I think this is due to temporary physiological causes rather than to permanent loss.

The discovery by Sasaki (1920, p. 181) that a varietal form of *Octopus macropus* has a radically different form of funnel-organ (cf. fig. 2D) from those hitherto described in the subfamily makes the systematic value of this organ uncertain. For the time being I am inclined to suspend judgment on this matter pending a confirmation of Sasaki's identification.

The "*locking*" apparatus. The ridges already noticed at the base of the funnel fit into shallow grooves on the inner edge of the mantle, and no doubt, when they are so engaged, the pallial cavity is sealed, as it is by the stud-and-socket articulation found in the Decapoda, and the contained water is concentrated in the locomotor jet expelled from

the funnel. In most forms the flanged ridges are weak, the receptor grooves shallow and the apparatus seems much weaker than the firm cartilaginous articulation of the Decapoda. On the other hand, it is continuous from side to side in many forms and affords a more extensive articulatory surface.

The *external surface* of the body is either smooth or covered by epidermal projections usually known as "sculpture." These are in the form of granules, warts or ridges. Around the eyes and in certain other areas these are much larger and sometimes branched and are known as

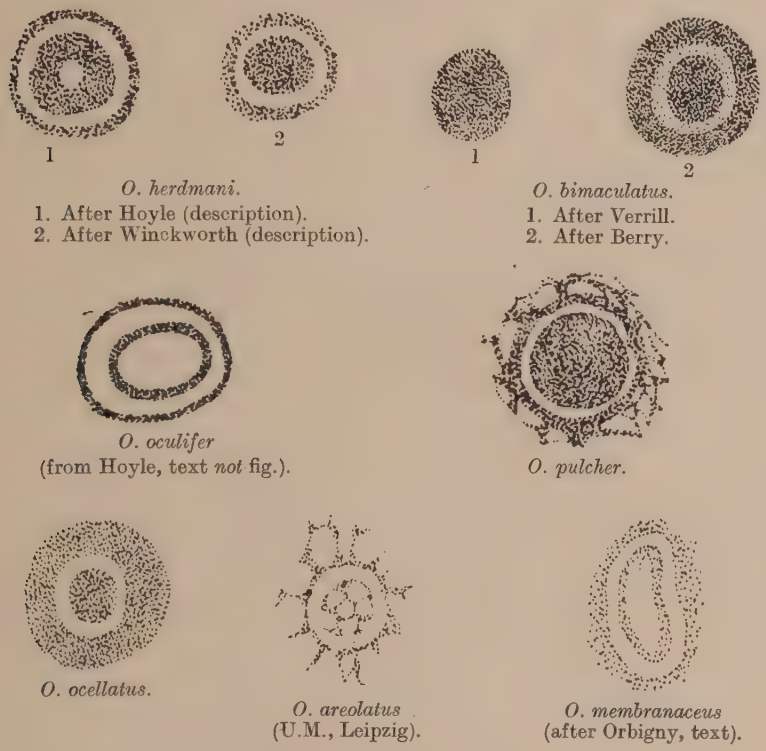

Fig. 3.—Ocelli of various species of *Octopus*.

cirrhi. In one case already investigated (*Octopus arborescens*) these cirrhi have a very peculiar structure and are highly contractile. The so-called "Kölliker's bristles" of the larva are discussed on p. 23.

Special colour-patterns are uncommon. The colour, when present, is usually diffused in irregular maculae. Characteristic patterns, however, are occasionally seen (*e.g.* rings in *Hapalochlaena lunulata*, *Octopus horridus*, and stripes in *O. chierchiae*, *ornatus*). A special feature is the occurrence of *ocelli* or circular patches of colour (often consisting of concentric rings) placed between the eyes and the edge of the web.

Skeleton. Skeletal structures in the Octopodinae are represented by the cephalic cartilages and "dorsal stylets" alone. The latter are, as Appellöf (1898*a*, p. 1) showed, homologous with the shell-rudiment of

Decapoda. They are situated one on each side of the middle line on the dorsal surface of the muscular mass immediately underlying the cuticle. I suspect that they may be of considerable systematic value; but for reasons given elsewhere (p. 39) I have not examined them in a large number of cases. In *Macrochlaena* they are absent, and in *Joubinia fontaniana* they are shorter and smaller than in other Octopodines (Dall (1909, p. 181) says "no internal shell or endostyle" (sic)).

Alimentary System. The horny jaws each consists of a beak (or cutting portion) and insertion plate (*palatine lamella* in the upper jaw, *gular lamella* in the lower jaw), on which the beak is fixed. The beak of the lower jaw is produced laterally as wing-like *rostral lamellae* and may be irregularly toothed.

The form of the jaws differs very little in the genera under review. In some forms the lower jaw is weak, the rostral lamellae being rather rudimentary and the beak poorly developed. Some variation is seen in the size of the beak relative to that of the insertion plate; but I have not explored this matter very fully.

The *radula* is essentially of carnivorous type. It is distinguished at once from the Decapod radula by (*a*) the frequent occurrence of two or more cusps on each side of the mesocone of the rhachidian tooth, and (*b*) the greater amount of differentiation in the individual teeth.

Each row of teeth always consists of a median tooth (rhachidian) with three teeth and a marginal plate on each side. The identity of these teeth with the "laterals" and "marginals" of other Molluscs is obscure. I name the first three side teeth "laterals" and the marginal plates "marginals."

The radula of the Octopodinae is unique among the Mollusca on account of certain growth-phenomena seen in the form of the median tooth. These phenomena, which were first noticed by Dall and briefly commented upon by Hoyle, were described fully by me (1925). The rhachidian teeth of any radula, when examined serially from the latest formed back to the oldest and most worn, are arranged in metamerically repeated series. In a simple case (e.g. *O. gardineri*) we find, if we compare the first formed tooth with those which succeed it, that the cusps of the second are not arranged like those of the first, while those of the third are again arranged differently. The fourth tooth, however, is like the first, the fifth like the second and the sixth like the third, the seventh again is like the first and so on, the same type of tooth recurring at every third row.* The series of rhachidian teeth therefore consists of a number of identical series metamerically repeated. The change of form in each series always involves the same phenomenon, viz. a change in the size and position of the small cusps (ectocones) on each side of the main cusp (mesocone). Thus an ectocone which is found close to the main cusp in the first tooth of a series will be found to be situated more externally in the next tooth, and in the third will have reached the margin of the tooth. In the fourth tooth this cusp disappears from the margin and appears in the position which it occupied in the first tooth and the centrifugal migration is repeated.

This change of position on the part of the cusps is of course the reflec-

* Inasmuch as the oldest (first formed) teeth are always very worn the seriation only becomes perceptible at about a third of the way along the radula from the worn to the "nascent" end.

tion of a rhythm in development in the radular coecum. The secretory process forming the cusps gradually shifts laterally in successive growth-periods and then resumes its activity in a more axial position. I have found a hint of this phenomenon in certain Gastropod radulae (e.g. *Peristerna*).

The process outlined above is complicated in many species by the fact

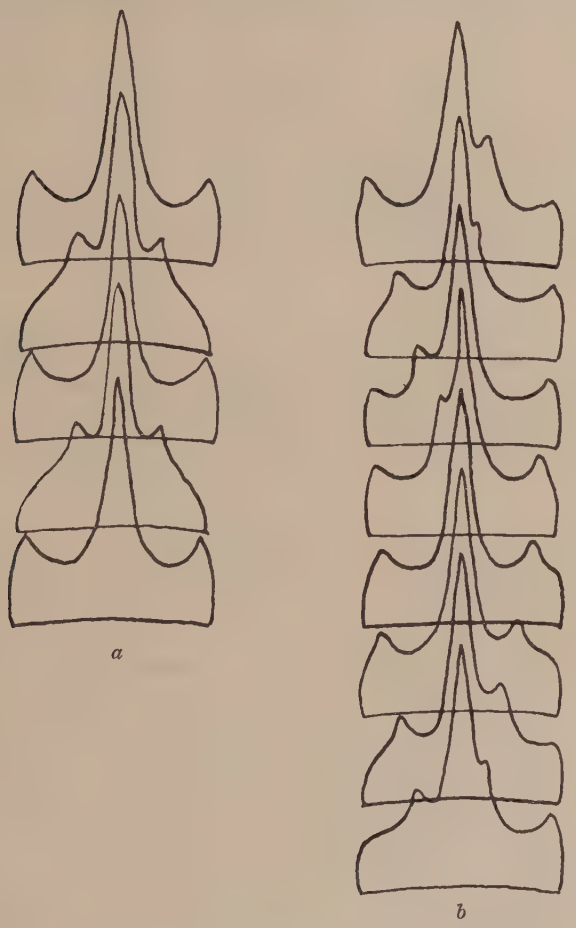

Fig. 4.—Diagrams of (*a*) simple, and (*b*) asymmetrical seriation in the rhachidian tooth of *Octopus*.

that the seriation is asymmetrical, *i.e.* the cusps on each side of the mesocone do not occupy similar positions. There is the same centrifugal displacement of the cusps, but it begins later on one side than on the other, and is completed (*i.e.* the ectocone attains a marginal position) later. The process of seriation and asymmetry is illustrated by the diagrams (Fig. 4).

By the aid of a simple formula it is possible to indicate the type of seriation. Simple symmetrical seriation is indicated by the letter A, asymmetrical by B, and the numbers attached to the letter indicate how

many teeth are occupied by a series. Thus A_5 means that the seriation is simple and is completed in five successive teeth.

At present I do not attach very great weight to the seriation in the diagnosis of species. In a general way species distinguished by other characters tend to have different types of seriation, but the data on p. 29 show that the individual variation in the type of seriation is considerable, and I think that the form of the radula undergoes changes with increasing age, so that the rhachidian tooth of young forms may have a different type of seriation from that found in old ones. The whole question requires very careful and special study.

The lateral teeth are of considerable diagnostic value. The first is a small unicuspidate tooth. The second is large; it has a long curved base, a large mesocone and often an entocone. When the latter is absent the mesocone may be placed at the inner margin, but more often it is nearer the centre of the base and a narrow inner "heel" is found. The third laterals have a long, usually slender and sword-like blade arising from a square or oblong base. The marginals are usually plain oblong plates.

No very marked evolutionary tendencies are to be seen in the radula. The most interesting is the presence of simple (unicuspidate) rhachidians in *O. defilippi* and *Enteroctopus* sp. and signs of degeneration in the first lateral and marginals of *Joubinia*. No Octopodine radula attains the degree of reduction seen in *Eledone rotunda* (Robson, 1926*a*, p. 1346).

The Ink Sac. In the Octopodinae, as in other Octopoda, the ink sac is involved in the liver, and in this respect the Octopoda may be regarded as more specialized than the Decapoda. The sac itself or reservoir (Girod) lies in a depression on the ventral face of the liver, and at least the initial part of the duct is free. In *Joubinia* and *Hapalochlaena* the duct is contained in a groove on the surface of the liver for at least half its length (fig. 5) and about three-quarters of its length is similarly placed in *Enteroctopus* and *O. defilippi*. In *Hapalochlaena* the reservoir is degenerate, and we see the initial stage of the process which ended in the complete disappearance of the organ in the Bathypolypodinae. There seems to be a good deal of variation in the degree to which the sac is covered in by the surrounding liver. In *O. vulgaris* it is completely invested by the capsule of the latter; in others it occupies a more superficial position. In *Cistopus* it is very deeply imbedded and is scarcely visible from the exterior.*

The Gills. These organs consist of a number of filaments suspended from opposite sides of a central axis in such a manner as to form two parallel and closely opposed series. Each of these series is known as a demibranch. The filaments are attached to the wall of the mantle-cavity at their tips (afferent border of the gill), and the whole gill forms a compact, roughly rectangular, mass. The filaments are very much folded. In the Octopoda generally the most striking feature in the evolution of the gills is the atrophy of these organs in relation to the abyssal mode of life (cf. Robson, *l.c.*). This atrophy is seen in the reduction of (i) the size and (ii) the number of filaments. The latter phenomenon alone is considered here. The average number of filaments in

* In the single specimen of *Paroctopus conispadiceus* (p. 205) which I have seen the sac is entirely free of the liver.

each demibranch in the Octopodinae is eleven, but there are species in which the number of filaments is considerably less, tending towards the condition found in the Bathypolypodinae and Cirrata. Thus it is as low as five or six in *O. horridus*. The inner demibranch, *i.e.* that facing the dorsal wall of the mantle-cavity, is somewhat less developed than the outer, even in species with a large number of filaments. In *Macrochlaena* and a few others its filaments are markedly reduced in length, though not

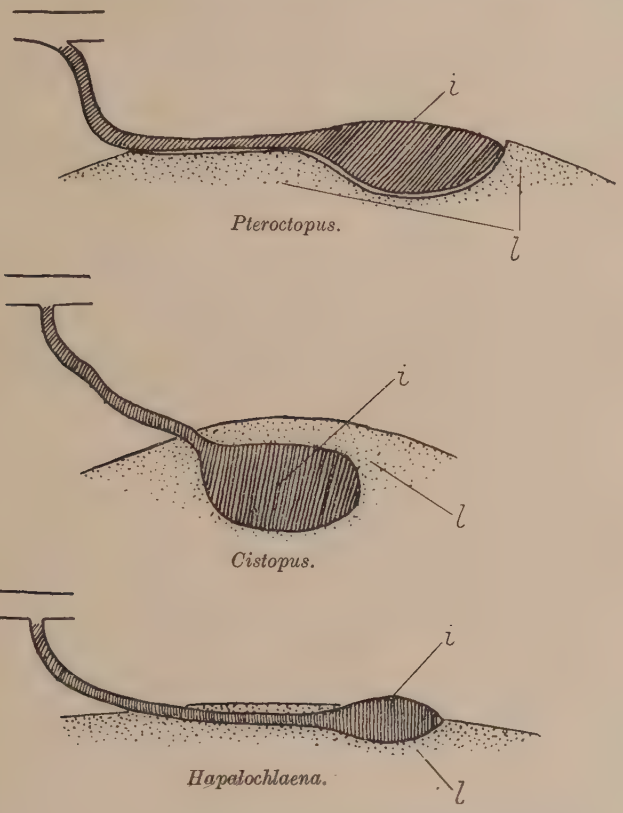

Fig. 5.—Diagrams illustrating the relation of ink sac (*i*) to liver (*l*) in the Octopodinae.

in number. I believe that neither sex nor age plays any important part in determining the number of filaments in the adult (Robson, 1926*a*, p. 1338, and this work, p. 28), though very young forms have fewer filaments than adults.

Reproductive Organs. The males and females are distinguished by certain differences of bodily proportion. I am not sure that the nature of these differences is yet understood. Naef says that the body of the male is narrower in the Octopoda generally (1923, p. 667, though cf. *O. macropus* (*l.c.* fig., p. 703)). Actually I have found (p. 25) that the male in *O. vulgaris* is relatively broader than the female (as in Naef's

figures, p. 703), though I agree that it is of a less full and rounded shape. Very probably the proportions vary with the season. The matter is in need of exact investigation.

It is generally held that in the Cephalopoda the females tend to be more numerous than the males. Pelseneer (1926, p. 42) states that the proportion in *O. vulgaris* is ♀ 2 : ♂ 1. In *O. bimaculatus* and *O. hongkongensis* Berry (1912*a*, pp. 280–3) found a slight excess of females. Isgrove, however (1909, p. 472), has already suggested that the numerical disparity may be more apparent than real, as the female breeds in littoral stations and is thus more often taken than the male. Figures in support of this suggestion have been published by me (1926*a*, p. 1325). Sometimes males and females are obtained in equal numbers and the males may even preponderate.

The structure of the male and female reproductive system has been fully explored by Brock (1879, 1882) and Marchand (1907).

Male System. The testis is apical (posterior) in position and may be sufficiently large to displace many of the adjacent organs. The *vas deferens* is long, slender and very much coiled. It ultimately passes into the long spermatic gland in which Marchand (1907) recognizes three main areas. This organ opens in common with Needham's organ and the " accessory gland " into a common duct. Needham's organ, in which the spermatozoa are stored, is usually long, cylindrical and pointed at its apex. The accessory gland is club-shaped. At the point where it enters the common duct a short coecum is sometimes found, the " appendix " of Marchand. The common duct terminates in the *penis*, which is partly external, partly internal. It is nearly always furnished with an appendage (" diverticulum " of Marchand). This diverticulum is usually globular or reniform, but may be long and slender (as in *Joubinia* and *Enteroctopus*). A second diverticulum also is found in *Joubinia*. Although the presence of spermatophores in the penis may alter its shape, they do not seem to modify the diverticulum.

For a long time I was under the impression that the long diverticulum of *Joubinia* was adventitious and merely due to its excessive enlargement by the spermatophores. I have to conclude, however, that it is a fixed and permanent feature for the following reasons :—1. The diverticulum of other forms often contains spermatophores and is not enlarged. 2. The enlargement occurs regularly in all the males of *Joubinia* and *Enteroctopus* that I have seen and in no other forms. (In *O. aegina* an analogous enlargement is found, but in a different part of the system.) 3. I have found the diverticulum enlarged without any spermatophores being present (see also Robson, 1929*a*).

The spermatophores have been well described in *O. vulgaris* by Marchand (1913), and recently Sasaki has attempted to use those of other species for systematic purposes. I have myself noted considerable difference in the structural details, and some of these may be correlated with the form of the hectocotylus.

The Hectocotylized Arms. The third arm of the right side is modified for copulation in all Octopodinae except *Scaeurgus* and *Pteroctopus*, in which the third arm of the left side is thus modified. The modification expresses itself in three ways :—(1) In most, but not all, species, the arm is reduced in length. (2) The velar membrane of one side of

the arm is converted into an open seminal channel by thickening and infolding of its rim. This channel terminates at the tip of the arm in (3) the hectocotylus proper, or end-organ (" Löffel " of German authors). Typically this has the following structure. A portion of the distal end of the arm is devoid of suckers and somewhat flattened dorso-ventrally. The seminal groove terminates in a conical papilla (the calamus) which is usually adjacent to the last sucker. Beyond this the surface (ligula) usually is longitudinally grooved. This groove may be very feebly developed or deep, well marked and provided with transverse ridges (laminae copulatoriae).

In certain forms the apparatus is feebly developed and the essential parts ill defined. I do not know if there is any seasonal change in its form, but I suspect that this may occur. Winckworth (1928, p. 49) also makes this suggestion. Ignorance on this point makes it difficult to assess the importance of the very undifferentiated organ in *Macrochlaena*, etc. On the other hand, there is a well-marked tendency in the group for the end-organ to become large and to occupy a progressively larger part of the arm. This process gives rise on the one hand to the long and pointed type of organ (*Paroctopus*) and on the other to the coarse, heavy Bathypolypoid type (*O. australis*, *Scaeurgus*).

Further modifications of the arms of the male are seen in (*a*) specially enlarged suckers, and (*b*) conversion of the suckers of the distal part of the arms into papillae (*O. chierchiae*).

For the use of the hectocotylized arm see p. 21. Within the same species there is very considerable variation in the form of the hectocotylus (cf. fig. 9). As examples of approximately the same size sometimes have well- or ill-defined end-organs the likelihood that this organ undergoes seasonal change is increased.

Female System. The ovary is apical and is sometimes so large that it displaces the adjacent organs (cf. Robson, 1921, p. 438). The system is very simple as compared with that of the male; but it has been very little studied. It consists, as in most of the Egopsida, of two oviducts which are divided into two parts, distal and proximal, by the development on their course of an " oviducal " gland. The proximal section (*i.e.* that which passes from the ovary to the oviducal gland) is usually the shorter.

Little is known concerning the nature of the oviducal gland in the various genera. A matter of considerable morphological importance is involved herein. In the Argonautidae Brock (1882) found a receptaculum seminis involved in the " oviducal gland." He stated that this structure does not occur in *Octopus*. Bergmann (1903), however, found evidence that part of the oviducal gland functions in *O. defilippi* as a receptaculum seminis, and on sectioning the organ in an example of that species I discovered ample evidence that he was correct. Sections of the organ in *O. vulgaris* also revealed the presence of spermatozoa in the gland; but the structure of the latter is not so complex as in *O. defilippi*. At the present moment I have not completed this study; but it will be of great interest to discover if this receptacular function of the " oviducal " gland, the activity of which has hitherto been regarded as limited to secreting the egg-capsules (cf. Meyer, 1913, p. 73), is found in many other species.*

* For a fuller discussion see p. 137.

Externally the oviducal glands are partly subdivided by a median constriction in some forms. Their size varies very considerably; but I am unable to say if this is due to differences in physiological activity. In *Bathypolypus* they always seem to be large. The distal part of the oviduct is in a few species expanded to form a vagina. The external female apertures are usually mere orifices in the wall of the pallial cavity. Occasionally, however, they open on well-developed genital papillae.

Structural Abnormalities, etc. Among the specimens which I have examined structural abnormalities are very uncommon, and the literature of this group contains few records of such phenomena.

There are at least three instances of bifid arms in *Octopus* (s.s.). Parona (1900, p. 4) records a subdivided dorsal arm in *Octopus vulgaris*, and Hanko (1913) described a fourth arm thus subdivided. Smith (1907) gave an account of a far more remarkable abnormality in *Octopus cephaea* (see p. 90), in which all the arms were divided. Lönnberg (1907, p. 51) describes a specimen of *Octopus patagonicus* which had only seven arms; " of the eighth not even a trace can be seen " (*id., l.c.*). I have described a very rare and striking abnormality in a specimen of *Octopus rugosus* from Curaçao (Robson, 1929). In this specimen there was a double hectocotylus, the second arm on the left side bearing a fully-formed ligula and calamus. The seminal groove, however, is incomplete.

Specimens showing signs of disease are singularly rare. I have opened the mantle-cavity of about 400 specimens in all and have noted only two cases of disease of the viscera and pallial complex. In one specimen there were abundant signs of kidney disease, the walls of one kidney being thickened and hardened. In another (a female) the oviduct was partly atrophied. I have discovered but one case of infection by parasitic worms.* The presence of calcareous concretions in the skin of *Pteroctopus tetracirrhus* described by Troschel (*q.v.*) may have been pathological (see pp. 23, 193, 197).

* The alimentary canal was not, however, opened in many specimens.

III. HABITS, ETC.*

The Octopodinae are an exclusively marine group of animals. Like the Amphineura and Scaphopoda among Molluscs and the majority of Echinoderms and Brachiopods (*e.g.*) among other groups, they seem quite incapable of living permanently in brackish water. No doubt they occasionally find their way into areas of low salinity, but I can find no record of their acclimatization to such habitats. They undoubtedly are to be found in estuaries. Winckworth (1926) records *Octopus hongkongensis* from Lake Tamblegam (a " sea-loch ") in Ceylon and Allen and Todd (1900, p. 151) state that *Octopus vulgaris* lives at a considerable distance up the Salcombe estuary. But when these records are closely examined it will be found that the animals live only in those estuaries of which the salinity is nearly equal to that of normal sea-water. Thus the salinity of the Salcombe estuary is not markedly different from that of the English Channel (Allen and Todd, *l.c.*); whereas in the Exe estuary, which is much fresher, *Octopus vulgaris* is absent (Allen and Todd, *l.c.*, p. 295).

There is a record of *O. vulgaris* in the River Crouch (Essex) and of *O. lunulatus* in the Swan River (Australia) (Brit. Mus.). Unfortunately no details are given in either case. Hoyle (1907*a*, p. 38) records *O. horridus* from the mouth of a freshwater (?) canal in E. Africa. On the other hand, the recent study of the fauna of the Suez Canal (Robson, 1927*a*, p. 321) revealed *Octopus horridus* at Toussoum (density 1034) and Kabret (density 1033–36). In the intermediate stations of lower density no Octopods were found. The number of occurrences is low and may not be significant; but, if representative, they suggest that these animals are better able to live in water the density of which exceeds that of normal sea-water, than in a density below that of the latter.

Most of the Octopodinae live in shallow water. Of 50 species of which the vertical distribution is given or may be inferred, no less than 33 are found in water of under 100 fathoms and 17 were taken in over 100 fathoms. Many species are recorded from rock-pools and reefs and can evidently tolerate exposure in the intertidal zone. In deeper water the family is principally represented by the Bathypolypodinae. Certain Octopodine forms are recorded from deep water, but it is not yet certain whether some may not be species of *Benthoctopus* and *Bathypolypus*. Our knowledge of the exact vertical range of these forms is subject to a limitation familiar to students of the fauna of deep water, viz. that, unless a specimen is taken in a closing-net, the record of the depth to which the net has been lowered cannot be accepted as that at which the animal was living. This matter has been discussed by me with special reference to the Octopoda (1926*a*, p. 1326). Actually we believe that the adults of this group are benthic or at least keep near to the bottom. Such animals are not likely to get into nets near the surface, when the haul is made at any considerable distance from the land; so that the statement that an Octopus has been taken in 500 fathoms may be reasonably taken at

* See Bartsch (Rept. Smithson. Instn., 1917, p. 347) for an interesting account of octopus-fisheries, attacks on Man, etc.

its face-value, even if the net used was not of the "closing" pattern. However, we do not know how strictly benthic these animals are. Certain well-known forms (*O. vulgaris*) seem to keep to the bottom and only swim off it when attacking their prey or avoiding an enemy (Hempelmann, 1926, p. 196). But we do not know if this is a universally developed characteristic, though I suspect that it is so. The young postembryonic stages of some Octopods are pelagic (Lo Bianco, 1903, p. 170; this work, pp. 23, 170); but no certain records of pelagic adults are known to me. Joubin (1900, p. 33) mentions that *O. vulgaris* was taken at an offshore station over 748–1262 metres (cf. p. 60).

As to the exact habitats of *Octopus* and its allies we can only speak very generally. They seem on the whole to prefer rocky bottoms in adult life, but some are found in muddy and sandy places, and in all probability some of the genera (e.g. *Pteroctopus*) are distinguished by special adaptations to burrowing in mud.

From all accounts the Octopodinae are wholly predatory and carnivorous. The prey consists mainly of Crustacea, supplemented by Molluscs. Lo Bianco (1909, p. 652) states that *O. vulgaris* feeds regularly on *Maia*, *Carcinus* and *Portunus*. *Haliotis* (Stephenson, 1925, p. 492) and various Lamellibranchs (Dautzenberg and Durouchoux (1913, p. 7), Joubin (1907*a*, p. 48) and Jeffreys (1869, pp. 144–5)) are mentioned as Molluscan prey. Kollmann (1875, p. 8) described a battle between a Lobster and Octopus (sc. *O. vulgaris*) ending in a victory for the latter. Hempelmann's account (*l.c.*) seems to suggest that *O. vulgaris* eats fish in captivity, but Tanner (1916, p. 22) noted that a captive specimen always refused that diet. Lo Bianco (*l.c.*) has shown that *O. vulgaris* paralyses its prey by means of a toxin secreted by the second pair of salivary glands. The nature of this toxin has been investigated by several workers and it seems to be a crystallizable alkaloid.

Little is known as to the enemies of Octopods. They are probably eaten by most of the larger carnivores of coastal waters. Lee (*l.c.*, p. 52) says that the Conger is amongst the worst enemies of the Octopus on British coasts. The means of defence against enemies which these animals possess seem to be numerous. Their strength and agility is considerable, and their habit of lurking in crevices of rocks must be of advantage. In addition the ink sac provides them with the means of baffling their enemies and the highly developed cutaneous system of chromatophores is said (Lo Bianco, *l.c.*) to enable them to assume a protective resemblance to their background.

There seems to be little doubt that *Octopus vulgaris* has a well-developed nesting or lair-making habit. Kollmann (*l.c.*, p. 14) has described the transport by this species of suitable stones for the making of the lair. Whether the nest is made for the protection of the eggs or for some other purpose is uncertain.

Cyclical Occurrence. Garstang (1900, p. 260) states that after being rare in the waters adjacent to Plymouth *Octopus vulgaris* became extraordinarily plentiful in 1900. Mr. R. Winckworth informs me that a similar "Octopus year" was noted at Brighton in 1913 and probably in 1922. Garstang (*l.c.*) is inclined to attribute the sudden increase in 1900 to the prevalence of optimum conditions in previous years. Such fluctuations in the numbers of a particular species are, of course, familiar

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to most naturalists. It is uncertain whether the above-mentioned increases in population are due to local environmental causes or whether the local population was augmented by migratory shoals coming into the Channel.

Autotomy and Regeneration of the Arms. It is well known that the Octopoda in common with other Cephalopods have the power of regenerating parts of lost arms, and I have seen many traces of this process in the specimens which I have examined. The subject is reviewed, and an account of the histological phenomena found during regeneration is given by Lange (1920).

Portions of the arms are often missing, and I have even found examples with *all* the arms reduced to mere stumps. No doubt this loss is often due to the attacks of enemies. It is, however, certain that it may also be due to autotomy (*Octopus defilippi*, Jatta (1896), Riggenbach (1901)), or to the animal eating its own arms (*Octopus vulgaris*, Eisig (1901), Lo Bianco (1899)).

Breeding Habits and Oviposition. The courtship and coitus of *Octopus vulgaris* have been studied by Racovitza (1894). The process consists essentially of the introduction of the extremity of the hectocotylized arm into the mantle-cavity of the female, during which operation Racovitza found that the animals remained a short distance apart. The male did not grasp the female during insemination, though it was seen on one occasion to hold the female with another arm for a short time previously to coitus. The exact use of the hectocotylus in manipulating the spermatophores is, however, very obscure and the significance of the various types of end-organ (see p. 17) is unknown. When we compare, *e.g.* the small and unspecialized hectocotylus of *Octopus vulgaris* with the large organ of *Scaeurgus* or *Paroctopus hongkongensis*, we are compelled to suspect some marked differences in the mode of insemination or in the spermatophores. The function of the enlarged suckers in the male (cf. Racovitza, *l.c.*, and this work, p. 9) and of the modified suckers of *Octopus chierchiae* is likewise unknown. Hempelmann (*l.c.*, p. 200) states that the males of "*Octopus*" have been observed fighting, presumably for the possession of certain females.

The eggs of very few species are known. Those of *Octopus vulgaris* and *Paroctopus digueti* are described very fully by Naef (1928, p. 70, 262 foll.) and Rochebrune (1896, p. 75). They are laid singly (*Paroctopus digueti*) or in clusters (*Octopus vulgaris*) and are encased in a capsule. One end of the latter is drawn out into a stalk by which it is attached. The following table gives the available records of the size of the eggs.

Species.	Authority.	Size (in mm.).
Octopus vulgaris	Naef (*l.c.*)	1 × 1·8–2
,, *salutii*	,,	,,
,, *macropus*	,,	,,
,, *defilippi*	,,	0·9 × 1·6
,, *rugosus*	Robson (MS.)	1·5 × 2·4–2·8
,, *ochotensis*	Sasaki (1920)	9 (length of ovarian eggs)
Paroctopus digueti	Rochebrune (*l.c.*); Robson (MS.)	3·0–3·5 × 9–10
,, *yendoi*	Sasaki (*l.c.*)	7 × 17 (ovarian eggs)
,, *conispadiceus*	,, (1917, p. 367)	30 (length of ripe ovarial eggs)

Lo Bianco (*l.c.*, p. 650) and Naef (*l.c.*, p. 263) state that the eggs of *Octopus vulgaris* are deposited during the summer (May–August). The size given by Sasaki for the eggs of *P. conispadiceus* is inordinately large and may possibly be an error.

The eggs are usually attached to a solid object, usually a stone or rock (Jatta, Fisher). There is, however, a well-developed tendency to place them inside shells of other Molluscs. This is noted by Perrier and Rochebrune (1894; *Octopus digueti*), Robson (1928*b*, p. 646; *Octopus rugosus*), Hornell (1922, p. 202; ? *Octopus rugosus*). Lonnberg (1907, p. 49; *Octopus fontanianus*) and Winckworth (1926, p. 325; *Octopus fontanianus* (?)) note the occurrence of adults inside the shells of *Voluta* and Chank. There is a specimen of *Octopus digueti* in the Musée d'Histoire Naturelle in Paris, which was found with its eggs in a broken bottle. These animals seem to have a very definite habit of entering any hollow object that will accommodate them. According to Orbigny (1840, pp. 69–70) this habit is exploited by Japanese fishermen in order to capture certain species. Lo Bianco (*l.c.*) relates that a specimen of *O. macropus* was taken inside a human skull fished off Posilippo.

Aristotle was the first to observe that the Octopus broods over its eggs. This observation has been confirmed by Lee (1875, p. 58), Schmidtlein (1879, p. 135), Lo Bianco (*l.c.*, p. 650), Monticelli (1921, p. 138) for Mediterranean forms and by Fisher (1923, p. 148) for *O.* (?)*apollyon* in California. The female cradles the eggs in her web and performs some kind of incubatory process by syringing the eggs with her funnel.

Parasites. Practically nothing is known of the parasites of Octopods. Lameere (1916, p. 1) described Dicyemids from *O. vulgaris* and several species of *Aggregata* are recorded from the same form by Dobell (1925, pp. 8, 20, 31).

Behaviour, etc. The behaviour of certain species has been studied by various workers and their results are summarized by Hempelmann (1926). Apart from the simpler reflexes involved in food-getting and mating, more complex manifestations have been noted, such as those involving memory and manipulative performance. Our knowledge of the behaviour of these animals is, however, very deficient and consequently the use of many peculiar structural features is unknown.

In common with the Decapoda these animals may justly claim to represent the climax of invertebrate evolution, in so far as strength, size and agility are concerned, and probably also in physiological efficiency. We do not, however, know how to rate them from the point of view of intelligence. Unlike the living Tetrabranchia and some of the Decapoda which are probably gregarious, the Octopodinae seem to be solitary,* and, if it is not reading too much into our evidence, irritable and ferocious. From their very obvious preoccupation with parental responsibility seen in nesting and brooding and their wary aggressiveness and furtiveness we receive the impression of a distinctive and peculiar disposition.

* The gregarious tendency noted by Garstang (*l.c.* p. 266) seems to have been exceptional.

IV. DEVELOPMENT.

The larval and postlarval stages of the Octopoda have been studied by Naef (1923, pp. 668, 686; 1928, p. 255 and foll.). His observations, though they relate to the Mediterranean forms, are no doubt relevant in general to the majority of Octopodine species. The particular life-histories of the majority of described species are practically unknown, however, and the determination of the various young forms which have been recorded must in consequence await a fuller exploration of the subject. We may note the following characteristics of young forms.

(1) The arms are very short relatively to the total length and are usually subequal in length. Marked differentiation in length is an adult feature. Thus in the planktonic stage the young *O. macropus* has arms equal in length (Naef, 1921, pl. 9, f. 1).
(2) The skin is usually covered with minute bristles. Naef (1923, p. 687) discusses the adaptive significance of these structures and considers that they may have a special value during the early (pelagic) stages of life.*
(3) Owing to the marked increase in size of the arms in the adult, the web which seems to grow less rapidly, is sometimes deeper in the larval stage (cf. p. 27). I think it is also more evenly developed in the young.
(4) The eyes are usually larger and more prominent.
(5) There appears to be a special type of larval coloration. Numbers of large, well-defined (usually light brown) chromatophores often occur on the dorsum and there are sometimes double rows of such chromatophores up the arms.

Naef states (*l.c.*, p. 686) that " altere Iugendstadien " (sc. about 4 mm. long, to judge by his text-figure 401) are already benthic and do not occur in the plankton.

Berry (1912*a*, p. 287) comes to the interesting conclusion that it is easier to make a specific diagnosis from young specimens than from the adult.

* These bristles have been specially studied by F. R. von Querner (*Zeits. f. Zellforsch. mikr. Anatomie*, 4Bd. Hft. 2, p. 237; 1926).

V. VARIATION IN *OCTOPUS VULGARIS.*

I give below the results of an examination of a number of characters in 21 specimens of *Octopus vulgaris*. Most of the measurements are expressed as percentages of the length of the mantle measured from the apex of the latter to the level of the eyes. The mean, maximum and minimum of the measurements obtained are supplied. The numerical data for individual specimens are deposited in the Zoological Department.

The recognition of species in this group, as already explained, is very difficult. *Octopus vulgaris* itself is, as a rule, tolerably distinct from its nearer Mediterranean relatives, *Octopus rugosus* and *O. macropus*, and many specimens can be referred without much difficulty to one or another of them. I have, however, seen individuals of intermediate appearance which cannot be readily referred to any of the three species. Each of these "species" exhibits a combination of characters which is not found in the others. Individuals are, however, frequently found which display recombinations of these characters. This fact must be carefully borne in mind in considering the variation of these animals.

The range of variation found in any sample of a species is, of course, dependent on the way in which the sample is taken. In closely allied species having many characters in common the result is also influenced by the basis on which we select our "array." It should be understood that individuals which in this work have been included in "*Octopus vulgaris*," because they differ in several characters from (e.g.) *Octopus macropus*, may actually resemble the extreme or even average types of *macropus* in one particular character. Thus the length of the arms of *Octopus vulgaris* is 63–86% of the total length, with a mean of 78%. The individuals of arm-length 83–86% resemble the average *macropus* in respect of that character rather than the average *vulgaris*. They are included in *Octopus vulgaris*, because they are *vulgaris*-like in the majority of their characters.

Data such as those supplied in this section are of interest, as they permit us to compare the variability of the various organ-systems. Thus of structures that can be actually measured the length of the arms is more variable (has a wider range) than that of the web. The interocular index is more variable still than the length of the latter. Of structures less susceptible to exact measurement the mandibles seem to be less variable than the radula. Finally we may gain some knowledge as to the effect of growth, sexual dimorphism and liability to lesion and distortion on the variation of certain structures. The number of individuals available for this study is rather low, and consequently the biometrical significance of the data is not very great. It is hoped, however, that as a contribution to a neglected aspect of Octopod systematics they may be of some use.

1. *The Width of the Mantle.*

The measurement from the apex (or posterior end) of the mantle to the line joining the centres of the two eyes is taken as " length of mantle," and the maximum width of the mantle is expressed as a percentage of this length; the figure obtained is the " width-index." The range of this index is extensive viz. *37*—62—*91*. The size of the animal seems to have some influence on the shape of the mantle. A series of nine large * specimens (average mantle-length 119 mm.) had an average index of *56*—64—*91*; a series of smaller animals (61 mm.) had an average range of *37*—58—*68*. The influence of sex in this character is, if anything, more marked, a series of eight males and eight females of the same average size having 68 and 57 respectively as their average width-indices. It is a little curious that the male should be broader, as one would expect that on an average the ovary would be larger and confer on the female a fuller mantle. Naef actually states that this is the case in *O. macropus* (*l.c.*, p. 703). It must be borne in mind, as pointed out elsewhere (p. 15), that the males may be broader, but the apical portion of the female body is usually rounder and fuller. I have, however, been repeatedly struck by the size attained by the ripe testis in male octopods. It is evident that the shape of the mantle can only be used for the discrimination of species with very great caution.

2. *The Interocular Width.*

The distance between the outermost point of the eyes is expressed as a percentage of the mantle-length (" interocular index "). This dimension varies rather considerably, viz. *31*—45—*62*; though its range is less extensive than that of the mantle-width. The difference between old and young specimens is not very marked (*31*—42—*51* for old examples, *38*—47—*58* for young), but the head is somewhat narrower in old specimens. The difference between males and females is less marked (♂, *40*—47—*58*; ♀, *32*—44—*58*). The head of the male thus tends to be a little wider.

3. *The Arms.*

(1) *Order of size.* The order of size of the arms is shown by the usual formula (p. 9). The formula 3.2.4.1. is most frequent and occurs eleven times in forty series; 3.4.2.1. occurs seven times; 2.3.4.1. four times. The remaining combinations (3.2.1.4., 2.4.3.1., etc.) were found only once or twice. The formulae of thirteen series were rendered uncertain by lesions, etc. Age and sex do not seem to have any influence whatever on the relative size of the arms in adults. The character is of some systematic value; but on account of the liability of the arms to damage it is not always available. Perhaps the most constant feature is the small size of the first arms.

(2) *Length of the arms relative to the total length.* The length of the longest arm is expressed as a percentage of the total length (arms + body). The range is fairly considerable, viz. *63*—78—*86*. The difference between old and young specimens in this respect is trifling and quite negligible, as is that between males and females. In younger specimens than those

* Large animals are not necessarily *older* than smaller ones, but it may be reasonably assumed that, on the whole, size is a fairly accurate index of age.

dealt with here the arms are relatively shorter and in the postembryonic stage (p. 23) they are shorter still.

4. *The Width of the Pallial Aperture.*

The width of the aperture is assessed according to the system described on p. 10, as " wide " (C), " half-open " (B) and " narrow " (A). Type B occurs four times in seventeen specimens, B–C seven times and C four times. Neither age nor sex have any effect on the variation of this character.

5. *The Funnel.*

The shape is so much subject to distortion that it is neglected here. The length of the free portion is rather constant. Expressed as a percentage of the total length of the organ it has a range of *41*—52—*65* in sixteen examples. The length is uninfluenced by age and sex.

6. *The Locking Ridge.*

No expression of the variability of this organ can be found. In all the examples I have examined it is continuous from side to side and well developed.

7. *The Funnel Organ.*

The general form is fairly constant, viz. **W**. There is some variation in (*a*) the thickness of the limbs, and (*b*) the length of the outer limbs, which are not always as long as the inner limbs. The organ is not always found in a good state of preservation, and is sometimes entirely absent. Whether this is due to periodical physiological change or the mode of preservation, I do not know. I suggest that the latter is responsible, as the organ is usually absent in specimens which by their flaccid condition seem to have been picked up dead rather than killed and properly fixed before preservation. Of sixteen specimens the organ was absent in seven; of the remaining nine the inner arms were longer than the outer in six, equal to them in three. Neither age nor sex has any appreciable influence on the occurrence or form of the gland.

8. *The Skin.*

In sixteen examples the sculpture of the skin varies as follows :—

(1) In ten examples the surface of the skin is raised into low, rather broad warts of irregular shape which are closely set. Single ocular cirrhi are present.

The sculpture of these examples is not appreciably different from that seen in living animals.

(2) In one example the sculpture is as in (1), but the cirrhi are absent or almost imperceptible.

(3) In one specimen the warts are multifid and widely spaced.

(4) In one specimen the cirrhi are present, but the character of the sculpture is uncertain.

(5) In one specimen both the cirrhi and sculpture are very obscure.

(6) In one specimen the warts are replaced by contiguous scales and the cirrhi are absent.

(7) In one specimen the sculpture is like that of (1), but the cirrhi are numerous.

I agree with the opinion which Naef (1923, p. 697) seems to express, viz. that as a result of softening (? the tissues having been fixed some time after death) the appearance of rather wide, low warts is produced from papillae which during life were more prominent and perhaps more widely spaced.

9. *The Web.*

The structure and method of designating the parts of the web have been already described (p. 7).

(*a*) *General form.* It is plainly difficult to find a convenient method of expressing the variation of a complex structure like the web. A web-formula, in which each section is lettered and arranged in order of size, is useful, but it is better to find an expression of the variation in respect of size exhibited by each sector. In the accompanying table each sector is shown with the number of times it occupies the first, second, third, fourth and last position in point of depth.

Sector.	Order of Size (number of times each position is occupied).				
	1st.	2nd.	3rd.	4th.	5th.
1–1 (A)	0	0	2	8	10
1–2 (B)	1	3	7	8	1
2–3 (C)	16	3	1	0	0
3–4 (D)	8	8	4	0	0
4–4 (E)	0	0	7	6	7

It follows that the most frequent order is :—

$$2\text{–}3,\quad 3\text{–}4,\quad \begin{matrix}1\text{–}2\\4\text{–}4\end{matrix}\Big\}\ \begin{matrix}1\text{–}1\\1\text{–}2\end{matrix}\Big\}\ \begin{matrix}1\text{–}1\\4\text{–}4\end{matrix}\Big\},$$

or, using the formula suggested on p. 8,

$$\mathrm{C},\quad \mathrm{D},\quad \begin{matrix}\mathrm{B}\\\mathrm{E}\end{matrix}\Big\}\cdot\ \begin{matrix}\mathrm{A}\\\mathrm{B}\end{matrix}\Big\}\ \begin{matrix}\mathrm{A}\\\mathrm{E}\end{matrix}\Big\}.$$

The variation in the position which any sector may occupy is fairly large; but 2–3 (C) and 3–4 (D) are regularly first and second in order; 1–2 (B) tends to be larger than 4–4 (E), and the latter is usually larger than 1–1 (A).

(*b*) *The depth of the web relative to that of the longest arm.* The depth of the deepest sector is expressed as a percentage of the longest arm. This percentage is very uniform and varies but little, the range being *15*—20—*25* for 22 specimens. The larger specimens have a slightly larger average, viz. 21, as compared with 19 for the smaller ones. There is no difference at all between males and females in this respect.

(*c*) *Disparity in level between the various sectors of the web.* The difference between the deepest and shallowest sections of the web is expressed as a percentage of the mantle-length. The range is very extensive, viz. *11*—31—*71* in 21 individuals. Age seems to be an influential factor in this case, larger specimens tending to have a higher "disparity index" than smaller specimens (average 32 in old specimens as against 24 in young ones). Sex has no appreciable effect.

10. *The Suckers.*

(1) *Maximum size.* The outside diameter of the largest sucker is expressed as a percentage of the mantle-length. The range of this index is *7*—13—*23*. The males differ markedly from the females in respect to this character, the largest suckers having a range of *12*—16—*23* in the male, and of *7*—11—*15* in the female. It will be noted that this is not a sex-limited character, as certain females tend to have markedly enlarged suckers. The relative size of the suckers is not noticeably influenced by age.*

(2) *Position of the largest suckers.* Either a single sucker or more usually a pair of suckers is markedly enlarged (see p. 9). Of thirteen specimens the large sucker or suckers were on the second arm in seven, on the third arm in five and in one animal they were on both the second and third arms. I believe that the third arm more frequently bears the largest suckers in the male, the second in the female.

Internal Structures.

11. *The Gills.*

The filaments of the inner and outer lamellae of each gill were counted and the four figures obtained in each individual were averaged. The range in the average number of filaments of each demibranch is very limited, viz. *8*—9—*10*. There is a slight amount of uncertainty as to which of the small terminal branchial tufts should count as a filament. Comparison of the age-groups shows that there is no difference between them as regards the number of filaments. The number of females in which the gills were well preserved was too small to justify a comparison with the males.

12. *The Mandibles.*

The character selected for measurement is the depth of the rostrum of the upper mandible expressed as a percentage of the total length of the mandible. Fig. 5*a* gives a key to this measurement, the length *ab* being made a percentage of *ac*. The average depth of the rostrum is 29% with a range of 22–37% (12 specimens), by no means a wide range, when the variability of other parts is considered. I feel, however, that the mandibles require special study, as the differences of shape are obscure and difficult to express. The variation within the species is probably neither more nor less than that of other organs.

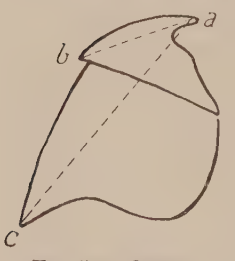


Fig. 5*a*.—*Octopus vulgaris*. Mandible.

13. *The Radula.*

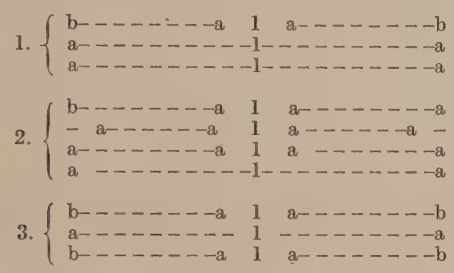
Eleven radulae were available for study. Of the twenty-six specimens in the collection some were in too poor a condition to justify examination, and it was considered desirable to keep a certain number intact.

(*a*) The number of teeth in each transverse row is constant. The average number of rows in the complete radula is 111, the maximum obtained being 140. In a radula having the average number of rows it is necessary to examine about the last 60 rows, the teeth formed earlier

* It is usually the old females which have enlarged suckers (cf. Robson, 1929*a*).

than this being usually worn and disfigured. Except in the rhachidian tooth no essential difference in form is to be noted between teeth at the growing end and those formed earlier.

(*b*) *Rhachidian tooth* (see p. 12). The seriation is asymmetrical (type B (Robson, 1925)) in six cases, symmetrical (type A) in four cases. One of the latter showed a "lag," the right-hand cusps being more eccentric than the left-hand ones. One specimen was anomalous in that some of the older teeth were symmetrical, while the later ones were asymmetrical. The number of teeth in a series varies very much. The six radulae of type B are as follows:—B_{3-6}, B_{3-5}, B_2 (irregular), B_3 (irregular), B_{2-4}, ?. The radulae with symmetrical seriation are again very variable in the cusp-succession and vary from A_2 to A_4. The following diagrams show examples of the types of cusp-succession found:—



It will thus be seen that the form of the rhachidian tooth is very variable both as to type of seriation and the number of teeth in a single series.

(*c*) *The first lateral tooth.* The base is straight in three out of eleven cases, arched and sinuous in the remainder. Naef (1921, pl. 16) and Meyer (1912, p. 31) figure straight bases. The inner end of the tooth is usually devoid of a cusp, but in one case the upper angle of the inner side practically attains that status. The ectocone is low to moderate in nine cases, prominent and high in two cases.

(*d*) *The second lateral.* There is a marked endocone in eight radulae. In two it is but vaguely indicated, and it is absent in one. The indentation of the base line varies from moderate to deep; but it is impossible to classify our examples satisfactorily.

(*e*) *The third lateral.* This tooth has always a moderate curvature. Naef (1921, pl. 16, fig. 5) shows a straight shaft, but I am satisfied that this appearance can be produced accidentally. The shaft varies somewhat in thickness, four radulae having rather solid teeth with chisel-shaped tips.

(*f*) *The marginal plates.* These are always present. In one specimen they were more or less degenerate. There is some variation in their antero-posterior depth, five being ranked as shallow, two as very shallow and two as deep. The plates are always about as long as the second lateral.

14. *The Pallial Septum.*

The length of the insertion of the adductor pallii medius is measured and expressed as a percentage of the mantle-length (Robson, 1928*d*). The range of variation is slight, 12—18—23. There is no appreciable differ-

ence between males and females or old and young specimens in the relative length of the septum.

15. *Reproductive Organs.*

A. *Male.*

(*a*) *The length of the penis* (including the diverticle).

The range in the length expressed as a percentage of the length of the mantle is 11—15—24. There is no noticeable alteration with age.

(*b*) *The shape of the penis.*

This is difficult to assess and no attempt is made here to give it an expression. Apart from accidental distortion the size and shape seem rather constant and the proportions of the diverticulum and penis proper are little variable. In two out of seven examples the terminal part was much longer than the diverticulum and in one the latter was circular, not conical. The shape of the diverticulum is not, as far as I can see, influenced by the presence of the spermatophores.

(*c*) *The hectocotylus.*

(1) *Length.* The average length of the ligula (measured from the distal end to the last sucker) is 4·4% of the third arm with a range of 3·3—5·5%.

(2) *Position of the calamus.* This is always below the middle point of the ligula.

(3) *Glandular "cheeks."* In five examples these are present in three, absent in two.

The number available for studying (1)–(3) is very low. No age-classes could be formed for testing the difference (if any) between young and old specimens. (See also p. 69.)

B. *Female Organs.*

(*a*) *Position of the oviducal aperture.*

This is on a level with the anterior end of the septum in two examples, 6 mm. behind it in one and 8 mm. behind it in a fourth.

(*b*) *The length of the distal part of the oviduct.*

This is 38% of the mantle-length on an average with a range of 37% to 45%. The organ is measured from the oviducal aperture to the point of entry into the oviducal gland.

(*c*) *The size of the "oviducal gland."*

The average length is 5·3% of the length of the mantle with average of 3·5% to 7·0%.

In none of the above features does there seem to be evidence of difference between young and old specimens, but again the number of individuals is not enough to justify comparison. I believe that the size of the oviducal gland may be influenced by its state of activity.

VI. PHYLOGENY AND CLASSIFICATION.

Our knowledge of the evolution of these animals is very defective. It is entirely dependent on the structure of the living forms, as there are no fossil representatives known at present. Moreover, there are but very scanty means of interpreting the various modifications of the arms, web, hectocotylus, etc., in the light of the animals' habits and mode of life. So little is known of the latter that the diversity of structure among the numerous genera and species appears meaningless at present. The only lines of bionomic divergence which are apparent in the subfamily are (*a*) the tendency seen in *Macrochlaena*, *Pteroctopus*, etc., to approach the deep-water Bathypolypodinae possibly in relation to a life spent in mud and sand, and (*b*) certain specialized modes of coitus probably indicated by the enlarged hectocotylus of *Paroctopus* on the one hand and that of *Joubinia* on the other.

The preparation of a scheme of classification based on the phylogeny of these animals is rendered additionally difficult by two circumstances. 1. Our knowledge of their structure is very defective and in many species no information is as yet available as to such important features as the funnel-organ, web, ink sac, eggs, radula, etc. As long as these structures remain undescribed, a very large number of the species known cannot be dealt with in a classificatory scheme based on these organs. 2. Even when these structures are known the recognition of genera, subgenera and groups of species is by no means easy. I have already shown that the species are difficult to distinguish owing to the very marked lack of correlation of characters. This tendency is to be seen in the larger groups. It is not easy to discover any broad lines of evolutionary divergence upon which a satisfactory classification could be founded. Marked structural divergence is indeed common; but it is usually seen in single characters, unaccompanied by other modifications. The subfamily seems to be broken up into a large number of disconnected and often monotypic groups rather than along well-defined lines of evolutionary divergence. The matter is complicated by the fact that the phylogeny of the suborder Incirrata is very obscure. If we knew the most primitive characteristics within the suborder, it might be possible to distinguish at least the most primitive of the Octopodinae from the more specialized. But if we review the chief organs and parts it will be found difficult to come to a conclusion as to which phase of these is to be regarded as more specialized and which as more primitive. As some such conception is, however, indispensable it will be necessary to consider this in detail.

I. *The Arms.* (*a*) In all probability the arms were primitively equal in length and the condition in which either the terminals are larger than the laterals or vice versa, is more specialized.

(*b*) I am uncertain if there is any significance to be attached to either excessive length or excessive shortness. I am inclined to think that lengthening of the arm beyond 80% is a specialization. This conclusion and also that stated under (*a*) are largely founded on the fact that in young forms the arms are usually equal and of moderate length (p. 23).

II. *The Web.* In the Decapoda the web is usually equally and moderately developed between the arms; and in the Octopoda a deep and well-developed web is found in the otherwise specialized Cirroteuthidae. I therefore believe that in the Octopodinae the web was primitively low and equally developed and that increase in its depth and asymmetry is a mark of specialization.

III. *The Funnel Organ.* It is difficult to decide whether the frequently occurring W or Ẅ shape is more primitive than the rarer VV shape. The shape most commonly encountered in the Decapoda is quite different, viz. ⩛, and it is possible to derive either of the Octopodine forms from it.

IV. *The Gills.* A reduction of the number of filaments in each demibranch is a marked feature of abyssal forms (Robson, 1926, p. 1338). It is, however, impossible to say if a number above the average (11) is a sign of specialization or whether it is a primitive feature. The Decapoda have many more filaments, so that the higher number may be an index of primitive status among the Octopodinae.

V. *The Hectocotylus.* The spoon-like ligula is a structure confined to the Octopoda, and no arguments from the other members of the class can be employed. In all probability the large ligula with deeply-folded sides and well-developed laminae copulatoriae, such as is seen in *Bathypolypus*, is a specialization, and the small undifferentiated ligula of (*e.g.*) *Octopus vulgaris* is more archaic.

VI. *The Radula.* The Octopodinae as a whole show very little variation in the lateral teeth and it is not easy to refer such modification as may occur to a more specialized or a more archaic status. The character of the rhachidian tooth is, however, more varied, and I think it is reasonable to suppose that the simpler type of tooth without elaborate seriation and multiple cusps is more primitive.

VII. *The Ink Sac.* In *Nautilus* there is no ink sac. In the Decapoda it is well developed and is not intimately associated with the liver. In those Octopoda which possess this organ it is imbedded in the ventral surface of the liver and covered over by the integument of the latter. It is uncertain whether the absence of the sac in the Cirromorpha is primitive or an adaptation to abyssal conditions. The absence of the sac in the Bathypolypodinae is probably a specialization. As far as I am able to see any difference in the degree to which the ink sac is involved in the liver in the Octopodinae I think it is legitimate to infer that the more superficial position is more primitive.

VIII. *The Mantle-aperture.* I believe that the widely-open mantle-aperture is a primitive feature. In *Nautilus* and the Decapoda the mantle is widely open, and it is only in the Cirromorpha and some of the abyssal Bathypolypodinae that it is partly or wholly closed.*

As regards the other characters of morphological value mentioned on p. 39, I do not think we can regularly employ them in treating of the evolutionary tendencies of the group. Some of them (eggs, suckers, dorsal cartilages, adhesive apparatus) are but little known, others are of doubtful value (sculpture and outline of head and mantle) or of special and isolated occurrence (interbrachial pouches), and they can scarcely be used in a general scheme.

If the conclusions arrived at in I.–VIII. are correct, then we would imagine our primitive Octopodine as having (1) rather short, equal arms, (2) a low equal web, (3) probably a **W**-shaped funnel-organ, (4) numerous gill-filaments, (5) a small, undifferentiated hectocotylus, (6) simple rhachidian teeth, (7) a superficially placed ink sac and (8) a widely-open mantle aperture.

Up to the present some fifteen † genera of Octopodines including those proposed in this work have been described. Of these two (*Schizoctopus* and *Amphioctopus*) are not recognized here. The first was mentioned casually (though with definition) by Hoyle ‡ (1886, p. 31). The only characters by which it is defined (a deep incision of the web between the dorsal arms and the occurrence of sculpture on the oral surface of the web are of trivial systematic value. *Amphioctopus* was proposed by Fischer for *Octopus membranaceus*, Quoy and Gaimard, the peculiar feature of which (lateral membranes of the body) is almost certainly of abnormal occurrence (see p. 7). Of the rest *Tritaxeopus* (p. 172) and *Pinnoctopus* (p. 184) are enigmatic forms, and since their description no student of the group has had an opportunity of studying them. *Macrotritopus* is likewise of problematical status (p. 167). The remaining genera have well-marked and individual characteristics, and the following view is taken of their relationship.

The features considered to be archaic (see above) in the group are realized most frequently in *Octopus* (s.s.). The complete array of characters assumed to be primitive is not, as far as I know, found in any one species (*O. defilippi* presenting the nearest approximation to this condition). Nevertheless the subgenus, as defined on p. 57, contains the greatest number of species having these characters most often associated. *Macroctopus* is probably a closely-related form. Among the others there are, I think, two definite lines of specialization, though the genera placed in these are not necessarily related and may resemble each other through convergence. The one manifests an approximation to the Bathypolypod type and is represented by *Pteroctopus*, *Macrochlaena* and *Hapalochlaena*. These genera exhibit some primitive traits. The web and arms are subequal. In *Macrochlaena* the hectocotylus is undifferentiated and

* I exclude from this generalization the special siphono-pallial fusions found in the "Oegopsida consuta" and Amphitretidae.

† I do not include *Pseudoctopus* (Grimpe, 1925, p. 93), as Grimpe himself noted that Naef had previously given the name *Paroctopus* to the group in question.

‡ Hoyle ascribes *Schizoctopus* to Steenstrup; but, as far as I (and others) can ascertain the name was never published by that author.

there is no appendix in the male genital tract. They all, however, show specialized features in (*a*) the soft gelatinous skin, (*b*) deep web, (*c*) narrow mantle aperture, (*d*) more or less reduced gills. As in *Hapalochlaena* the ink sac is manifestly reduced, it should perhaps be regarded as the most evolved.

The other main line of specialization is represented by *Joubinia*, *Enteroctopus*, *Scaeurgus* and *Paroctopus*. Of these the first two are obviously allied and exhibit the same tendency. It consists of the development of a long penial diverticle in the male genitalia. Some marked specialization of the hectocotylus is seen in this group. In *Paroctopus* the hectocotylus tends to be conspicuously enlarged and the eggs are much larger than in other forms. This genus was proposed by Naef for *O. digueti*, the ovipository habits of which are well known. I include *O. hongkongensis*, *O. apollyon*, *O. conispadiceus* and *O. yendoi* in this genus, though I think the evidence suggests that *O. apollyon* (to which *O. hongkongensis* is closely related) has small eggs. All these forms have a large hectocotylus. I believe that *O. californicus* and *O. dofleini* may belong to this group; and it is possible that more of Sasaki's species (1920) should be included here.

Cistopus, which has the remarkable feature of well-defined interbrachial pouches of unknown function, is worthy of a separate generic position. Its low web and plain tricusped rhachidian teeth ally it with the more primitive Octopod radicle.

There remain for consideration *Macroctopus* and *Macrotritopus*. These forms do not, in my opinion, show the same degree of differentiation as the forms hitherto treated. The former is very closely allied to one of the subdivisions of *Octopus*. The number of its gill-filaments is remarkably high and the locking apparatus may be primitive. On the other hand, if all the accounts are to be believed, the arms of the female are peculiarly specialized in the same way as they are in *Eledone* and in the male of *O. chierchiae*. *Macrotritopus* is of very doubtful value as a separate group. It is only distinguished from *Octopus* by its large third arms and is at present principally known from young specimens.*

Octopus chierchiae is remarkable for the modification of the distal suckers of all the arms in the male. *O. fusiformis* and *O. teuthoides*, which have very narrow squid-like bodies and arms exceedingly short even for the immature state of the single individuals by which they are represented, possibly deserve subgeneric recognition, though I see no gain in raising them, and perhaps one or two more slender squid-like forms, to that rank until they are better known.

With regard to the occurrence of subdivisions within the large subgenus *Octopus* (s.s.) the difficulty encountered in dealing with the genera makes itself felt in an acute form. Very many species are known by only a few characters, and it is difficult to assemble data on a sufficiently large body of species to make subdivisions of any value. So far as our information goes at present I believe, however, that the following groups can be recognized.

1. A. A large radicle of forms which are more or less like *O. vulgaris*. The web is bilaterally symmetrical and of moderate depth, the arms are uneven (the laterals being larger than the terminals)

* There is some possibility that these may be young examples of *Scaeurgus* (see p. 168).

and of moderate length (about 80%), the radula has an A_3 rhachidian and the hectocotylus is from 1·5 to 5·5% of the arms. The skin is usually covered with coarse simple warts.

2. A smaller number of other groups illustrating divers tendencies of which we may recognize :—

B. (*a*) Arms, 1 2 3 4; web, A B C D E ; hectocotylus, 6% or more; arms long (over 83%). (Group of *O. macropus*.)
(*b*) As in 1, but arms short (average 76%). (Group of *O. leioderma*.)

C. Arms, $\left.\begin{matrix}4\\3\end{matrix}\right\}21$; web, $\left.\begin{matrix}D\\E\end{matrix}\right\}$C B A (A very shallow). (Group of *O. egina*.)

D. Hectocotylus long; arms short (under 80%); funnel-organ double. (Group of *O. pallida*.)

E. Funnel-organ with median limbs far larger than lateral. (Group of *O. tenuipulvinus*.)

F. Body long and narrow, arms usually short, web subequal. (Group of *O. fusiformis*.)

G. Arms very long (over 83%); web low and subequal; the radula with a unicuspidate rhachidian; a receptaculum seminis known to occur. (Group of *O. defilippi*.)

H. Arms short, web deep (over 30%), hectocotylus Bathypolypoid. (Group of *O. australis*.)

I have arranged under these groups those species which have been adequately described. It will be apparent, however, that, as the descriptions are often defective in one or more material respects, many species are given a position on somewhat debatable grounds. I have tried, however, to assess the position of each species on as comprehensive a basis as possible, and have, in one or two places, been guided by general facies (as indicated in the descriptions) rather than by any particular association of characters. There is a large residuum of forms which cannot be placed in this scheme. These and a certain number of juvenile forms are placed in a separate category. Species of which no data are available or the descriptions of which are so defective that they cannot be properly distinguished are placed in a separate list on p. 214.

At present the large group of N.E. and N.W. Pacific species do not lend themselves to satisfactory grouping. Those placed in *Paroctopus* seem to form a natural assemblage. They have some affinity with those which I have placed in Group D of *Octopus* (s.s.), and some of the species temporarily arranged in that group may eventually be transferred to *Paroctopus* when something is known of their reproduction. *Paroctopus* also has affinities with the *leioderma*-group of *Octopus*. On the other hand, the affinities of some of Sasaki's species (1920) are by no means clear, and we await a more complete description of them.* *O. alatus* and probably *O. tsugarensis* seem to have long penial diverticula, which suggests relationship with *Enteroctopus*. Finally the Mediterranean *Octopus salutii* may be ultimately placed with the Pacific forms, as it has, like them, a long narrow hectocotylus. At present, however, it cannot be accommodated in any of the recognizable groups.

* For example, there is a tendency among them to exhibit the *O. macropus* arm- and web-formula. This has led me to suspect affinity with *macropus* and to place certain forms that cannot be accommodated in *Paroctopus* close to the *macropus*-group. I admit, however, that the position of *O. tsugarensis* is very ambiguous.

VII. GEOGRAPHICAL DISTRIBUTION.

The Octopodinae are widely distributed in all temperate and tropical seas. They do not occur in high latitudes and the limits of their dispersal toward the Arctic and Antarctic circles may be thus summarized. In the N. Atlantic they are not found north of a line drawn from the Firth of Forth to New York * (approximately along the isotherm of 10° C.). North of this line they are replaced by Bathypolypods and *Eledone*. In the South-east Atlantic, *Octopus* (s.s.) is not found south of Tristan d'Acunha (isotherm of 15° C.). On the south American mainland the limit is vaguer, as the generic position of several Patagonian forms is uncertain. Representatives of the genus reach about 52–53° S. in S. Patagonia (isotherm of 8° C.). The subfamily is, however, better represented by *Joubinia* and *Enteroctopus* in the Magellanic region (isothermal limits 6–10° C.). Further south towards the Antarctic Circle *Eledone* seems to replace the Octopodinae. I am as yet a little uncertain as to the southern limits of the group, as the generic position of certain recorded forms (e.g. *Octopus* sp. Joubin, 1906) is not known. In the Indo-Pacific area the Northern limit seems to be the Aleutian-Kamschatkan region (about 3° C.), where forms probably referable to *Paroctopus* are reported. Again, the generic position of many N. Pacific forms is not known. I suspect that many of the Japanese forms described by Sasaki are referable to *Paroctopus*. In the Southern Ocean true *Octopus* is found off the island of St. Paul and in Tasmanian waters, 38–40° S. (isotherm 15° C.), and the nearly allied *Macroctopus* off the New Zealand coast and Campbell Id. (50° S., isotherm of 8° C.). *Joubinia* is also found off Campbell Id. The above-mentioned ambiguity as to the position of the Magellanic species of *Octopus* is applicable to those of the west coast of Patagonia.

In short, we may say that the Octopodinae are found in water of a mean annual temperature usually not under 10° C. and that they are replaced in colder water mainly by the Bathypolypodinae in the north and the Eledoninae in the south. True *Octopus* is an inhabitant of warmer water than *Joubinia*, *Enteroctopus* and *Paroctopus*.

Concerning the detailed distribution of species very little can be said until more work has been done on the variation and identity of the species themselves.

The following points are to be noticed :—

(1) There are many regions of the world of which the Octopodine fauna is very imperfectly known. Little information has been published concerning their occurrence on the east coast of N. and S. America, Western Central and South America, the coasts of China, and of West Africa from the Cape Verde Islands

* I am indebted to Mr. C. Johnson of the Boston Society of Natural History for the information that there are no records other than those of Verrill for the New England coast. The only species found in that area is *Bathypolypus arcticus*.

southwards. The result is that any attempt at dividing the various oceans into regions on the evidence of this group is more or less valueless at present.

(2) Certain species are remarkably widely diffused. *O. vulgaris* and *macropus* seem to range from the Mediterranean to Japan. *O. rugosus* is found in nearly all the subtropical and tropical waters of the world (with the possible exception of the E. Pacific). *Scaeurgus unicirrus* is found in the Mediterranean, Indian Ocean, Japan and Hawaiian Islands. The identification of forms from regions so widely apart may be questioned; but I am satisfied that the range of the species above mentioned is correctly stated.

(3) The Magellanic region and the North Pacific seem to be foci of local differentiation, giving rise to fairly distinctive groups. The rest of the world is occupied by a population in which peculiar local faunas are difficult to distinguish and the individual range of species is wide.

VIII. MEASUREMENTS: BIBLIOGRAPHICAL METHOD: ABBREVIATIONS.

(*a*) *Measurements.*

The method of taking the measurements given here and in the table (pp. 42–55) is stated under the various organs in section V. In most cases the actual measurement is reduced to a percentage of the dorsal mantle-length measured from the apex to a point midway between the centres of the eyes. Usually this is expressed simply as an index number. Thus "suckers 15" means 15% of the mantle-length. Certain special cases are treated differently. Thus the depth of the web is given as a percentage ("web-length 30") of the longest arm and the length of the ligula as a percentage of the total length of the hectocotylized arm.

In preparing the tables on p. 42 I have been faced with the difficulty alluded to on p. 4 that in the past no standard method of measurement has been used. The measurements used in this work are those most commonly employed, but occasionally it is impossible to bring the measurements given by an author into line with these. Sometimes, therefore, I have had to make approximations. When this is done I have indicated the fact by a query (?), unless it is otherwise apparent that the figure given is of this nature.

The treatment of Dr. Stillman Berry's valuable data (1912*a*: 1914*a*) requires special mention. He sometimes gives the main body-length as "tip of body to base of dorsal arms." As I understand this measurement it is a little longer than my standard apex-eye length, and I have consequently obtained the latter by subtracting a small amount from Berry's apex-base of arms length. The amount subtracted is proportionate to the size of the animal. Thus in Berry's data for *Octopus leioderma* (1912*a*, p. 288) "apex-base of arms" is given as 45 mm. in the type specimen. I have subtracted 5 mm. from this and treated the apex-eye measurement as 40. Another method of obtaining the apex-eye length is to subtract the arm-length (maximum) + x mm. from the total length (if given), x being a small amount proportionate to the size of the animal and equivalent to the distance from the base of the arms to the eye. "Base of the arms" as used by sundry authors is actually vague; the arm-length should always be most precisely defined (*e.g.* "tip of arms to outer edge of lip").

(*b*) *Bibliographical Method.*

In drawing up the bibliography of each species an attempt has been made to give only the essential references. In the past it has been part of the tradition of careful monographers to include under each species *every* reference that has been made to it. This practice is often carried to quite

unnecessary lengths even to the inclusion of MS. names and valueless quotations from popular works. In the present work, in order to avoid a cumbrous and useless bulk, I have usually excluded (*a*) all references which are verbatim quotations from other authors accompanied by copies of earlier figures, (*b*) extracts from purely nominal lists of species from areas covered by earlier references, (*c*) geographical references which are loosely or generally expressed ("English Channel," etc.) or relate to places immediately adjacent to previously noted localities. The bibliography of each species contains references to such works only as are of systematic or distributional importance. The former is interpreted fairly broadly. Thus the lists contain references to papers dealing with habitudinal peculiarities and internal structures as they may be of systematic value. They do not record papers on physiology, on experimental work or on miscellaneous subjects, such as psychology, regeneration, etc.

(*c*) *List of Abbreviations used for Names of Institutions.*

Brit. Mus.	= British Museum (Natural History).
R.S.M., Edinb.	= Royal Scottish Museum, Edinburgh.
M.H.N., Paris	= Musée d'Histoire Naturelle, Paris.
Z.M., Berlin.	= Zoologisches Museum, Berlin.
M.U., Leipzig.	= Museum der Universität, Leipzig.
M.U., Jena.	= „ „ „ , Jena.
Senck. Inst.	= Senckenbergisches Institut, Frankfurt a/M.
R.M., Leiden.	= 's Rijks Museum, Leiden.
U.S.N.M.	= United States National Museum.

Examination of Specimens and Characters used in Taxonomy.

The number of characters which should be examined for taxonomic purposes, especially in the discrimination of genera, is very considerable. I doubt very much whether a really satisfactory phylogeny of this group will be produced until the anatomy of each group of species is completely known. Naef (1923, p. 691) recommends that the following characters should be used in conjunction with one another for the diagnosis of genera:—(1) size of the eggs; (2) outline of head and mantle; (3) relative arm length; (4) form of the web; (5) sculpture; (5) funnel-organ; (7) presence of lateral folds or fin-rudiments (?); (8) the size of the mantle-aperture; (9) form of the radula; (10) ink sac; (11) consistency of the skin; (12) the presence of interbrachial pouches; (13) hecto-cotylus and (14) occurrence of abnormal extremities on the arms of the mature male. I have no doubt that the gills, suckers, "dorsal stylets," form of the "adhesive apparatus," salivary glands, crop, etc., would also yield important characters. In a work such as this, however, it is necessary to limit one's examination, and, in addition, it must be pointed out that in dealing with forms like the Octopods, when few specimens are available, it is often undesirable to dissect the whole animal, as it would in most cases leave the latter in an almost unrecognizable condition. I have in all cases opened the pallial cavity and funnel, and in many instances I have examined the radula and ink sac. I have unwillingly abandoned the study of the "dorsal stylets," as their extraction usually damages the shape of the mantle too much.

IX. SYNOPSIS OF CLASSIFICATION.

The genera recognized in this work are enumerated below, together with the genera of the Bathypolypodinae. Although the latter are to be treated in Part II, I consider it desirable that at least a provisional arrangement should be published now, so that the position of the various species originally referred to *Octopus* and now placed in the Bathypolypodinae may be indicated.

Family Octopodidae, Orbigny.

Subfamily I. Eledoninae, Grimpe.

,, II. Octopodinae, Grimpe.

Genus 1. *Octopus*, Lamarck . . . . (pp. 56–182).

Subgenus i. *Octopus*, Lamarck . . . (pp. 57–167).
ii. *Macrotritopus*, Grimpe . . (pp. 167–172).
iii. *Tritaxeopus*, Owen (?) . . (pp. 172–173).
iv. *Macroctopus*, Robson . . (pp. 173–175).
v. *Enteroctopus*, Rochebrune & Mabille (pp. 175–182).

2. *Cistopus*, Gray . . . . (pp. 182–184).
3. *Pinnoctopus*, Orbigny (?) . . . (pp. 184–186).
4. *Joubinia*, n. gen. . . . . (pp. 187–191).
5. *Scaeurgus*, Troschel . . . (pp. 191–193).
6. *Macrochlaena*, n. gen. . . . (pp. 193–195).
7. *Pteroctopus*, Fischer . . . (pp. 195–197).
8. *Paroctopus*, Naef. . . . . (pp. 197–207).
9. *Hapalochlaena*, n. gen. . . . (pp. 207–214).

[10. *Schizoctopus*, Hoyle (Steenstrup MS.)]
[11. *Amphioctopus*, Fischer]

,, III. Bathypolypodinae, Robson.

12. *Bathypolypus*, Grimpe.
B. arcticus (Prosch.). (*O. bairdii*, V'll., *O. groenlandicus*, (Dewhurst), synonymous).
lentus (Verrill).
obesus (Verrill).
sponsalis (Fischer).
faeroensis (Russel).
valdiviae (Chun).
grimpei, Robson.
(?) *abruptus*, Sasaki.*

13. *Benthoctopus*, Grimpe.
B. piscatorum (Verrill). (*O. normani*, Massy, synonymous).

* There is no ink sac in specimens of this species sent to me on loan from the U.S. National Museum.

januarii (Hoyle).
ergasticus (Fischer). (*O. profundicola*, Massy, synonymous).
(?) *salebrosus* (Sasaki).*
(?) *hokkaidensis* (Berry) (= *glaber*, Sasaki, 1920).
berryi, Robson.
sasakii, Robson.
(?) *hyadesi*, Rochebrune & Mabille.
levis, Hoyle.

14. *Grimpella*, Robson.
G. thaumastocheir, Robson.

15. (?) *Atlantoctopus*, Grimpe.
A. lothei (Chun).
pseudonymus, Grimpe (= "*O. levis*, Hoyle," Joubin, 1906).

16. *Haptochlaena*, Grimpe.
H. chuni, Grimpe.
alberti (Joubin).

A new genus is to be defined in Vol. II for "*Polypus pricei*," Massy (1916*a*, *non* Berry).†

Incertae Sedis.
Polypus hoylei, Berry.
„ *pricei*, Berry (*non* "*P. pricei*, Berry," Massy, 1916*a*, see above).

* There is no ink sac in specimens of this species sent to me on loan from the U.S. National Museum.

† Since preparing the discussion on this form (p. 219) I have received Massy's Arabian Sea specimens on loan from the Indian Museum and am able to state that there is no trace of an ink sac in them.

X.—TABLE OF

For explanation of the measurements in columns 1–9 and 11, see "Variation" and p. 38.
The rhachidian formula given

Unless otherwise stated the figures given are index-numbers

		1. Dorsal length of mantle (mm.).	2. Width index.	3. Inter-ocular index.	4. Arms, formula.	5. Arms, length.	6. Gill-filaments.	7. Diameter of suckers.
I. *Octopus.* (i) *Octopus* (s.s.). A. Group of *O. vulgaris.*								
1. *vulgaris*	Brit. Mus., etc. ♂♀	66–185	37–62–91	31–45–62	3.2.4.1. etc.	63–78–86	8–9–10	7–13–23
2. *rugosus* (*a*) Atlantic	,,	27–71	60–70–88	—	2341	68–78–85	8–9–11	9–12–15
(*b*) Indo-Pacific		26–68	59–73–100	—	,,	69–77–84	,,	8–12–16
3. *verrucosus*	,, ♂	80	68 (Hoyle's figures)	50 (Hoyle's figures)	2.3.4.1 ?	80	? 10	26
4. *carolinensis*	Verrill	23	90	90	2.3.4.1 or 2=3.4=1	76	—	9
5. *pentherinus*	M.N.H., Paris Rochebrune and Mabille.	61(?)	50	70(?)	3.1.2.4(?)	83(?)	—	13(?)
6. *tonganus*	Brit. Mus. ♂♀ Massy, 1916A Hoyle, 1905	30–32–38	57–73–100	61–64–80	3421 3241 2431	81–84–88	7–9–12	21, type (♂)
7. *bimaculatus*	Verrill Berry, 1912	70–97 45–85(?)	107–85 77–64	64 40–55	3421 3241 3214 3412 2431	88–81 71–87	8	22–31
8. *tenebricus*	Brit. Mus.	16–19	57	53	? 2=3=4.1	84	5–7	8
9. *mimus*	Gould	? 75	66	32	3241	85	—	13 ?
10. *duplex*	Brit. Mus. types ♂♀ Berry, ♀ Joubin, ♂♀	13–25	94–61	63–52	2431 2=431 4231 etc.	68–76	? 6	14
11. *oculifer*	Hoyle, 1904*a* ♀	15	86	93	2=314 2341	78	—	15
12. *berenice*	Brit. Mus. ♀	18	83	66	3=241	78±	—	16
13. *hoeki*	R. M. Leiden ♀ type	65	40	24	3241 3421	71	—	9·2
14. *herdmani*	Hoyle, 1904*b* ♀	? 95 (see p. 83)	61	49	4=231 3241	78	—	—
15. *vitiensis*	Brit. Mus. ♀ type Appellöf Wülker	16–30	71	84	2=3.1=4 3.2.4.1 etc.	72–3	6–7	13

MEASUREMENTS.

Under column 10, "R" = rhachidian tooth; "1 L, 2 L," etc. = first and second laterals.
is that which occurs most often.

(p. 38) and usually represent maximum, mean and minimum.

8. Web formula.	9. Web, depth.	10. Radula.	11. Hectocotylus, length of ligula.	12. Sculpture.	13. Colour.
C.D.B.E.A. etc.	15–20–25	$R = B_{2-6}$ 2L, entocone usually present.	3·3–4·4–5·5	Very close irregular warts.	Yellowish brown, etc.
C.D.B.A.E. "	15–24–33 13–23–35	$R = A_{2-4}$ 2L, entocone usually present in (*a*), absent in (*b*).	1·7–3·4–6 2·2–5–8·2	Granules or fine warts, occasionally multifid.	Reticulated with purple mainly on head, web and arms.
C.D.B.E.A.	18	—	·7	Dense, close irregular warts.	—
Lateral sectors > dorsal and ventral.	Over 25%	—	—	Minute, prominent warts; no ocular or dorsal cirrhi.	Dark purplish-brown above, orange and brown below.
B=C=D.A.E.*	22*	—	—	Smooth.	Deep violet, pale orange maculae, dark purple maculae.
BDCEA CDBEA	11–18	$R = A_2$ 1L, very large. 2L, no entocone heel present.	1·1 type.	Mainly smooth, a few tubercles.	"Buff densely covered with dark brown chromatophores" (Massy).
CBDAE	18 ?	—	1·4–1·7	Prominent unequal warts.	Dark brownish grey, sometimes clouded.
DCBAE	15	—	3·7	Smooth; a few scattered cirrhi.	Uniform dark purplish-brown.
CDBAE	27 (see p. 81)	—	—	Coarse irregular warts.	Orange-ochre, blue marbling and dark transverse crescents on arms and web.
C=D=BAE Sc. A=E (Berry).	23–26	—	?	Simple granulations.	Slate grey or faint purple above; warm creamy-brown laterally.
E>A	32 (?)	—	—	Granular; no cirrhi.	Dull violet shading into ochre below. Ocellus present.
CDA=BE Sc. subequal.	18	—	—	Simple and multifid warts. See p. 84.	—
D=C.B=E.A	19	—	—	Originally warty. Type very much worn.	? Purple.
? C.D=E.A=B	26	—	—	A large number of prominent warts, cf. text, p. 86.	Dull brownish-grey, paler below. Ocellus.
C.B=E.D.A	33	—	—	Sparsely granulated, ocular cirrhi.	—

		1. Dorsal length of mantle (mm.).	2. Width index.	3. Inter-ocular index.	4. Arms, formula.	5. Arms, length.	6. Gill-filaments.	7. Diameter of suckers.
16. *microphthalmus*	Goodrich, 1896, ♀ Massy, 1916A, ♀	* 31–36	58–64	38–48	3.4=21 4=32=1 123=4	69–72	8	4·8–5·6
17. *cephaea*	Brit. Mus. ♂♀	85	58	35	3241	83	? 7–8	16
18. *horridus*	Brit. Mus. ♂♀ Hoyle, '05.	31–21	64–89	54–77	4321 3421 etc.	80–85	About 6	10–13
19. *globosus*	Appellöf, 1898 Massy, 1916A	15–35*	82–100	70–80	2413 2341	77–81	—	17–13
20. *cyanea*	Brit. Mus. type ♂ Robson, 1921 Berry, 1914*a* Massy, 1916A	125–56	52–67	36–51	3241 3421 2341 4321 etc.	78–83	9–10	♀ 8 ♂ 12–17
21. *tetricus*	Brit. Mus. ♂	69	72	47	3241	81	9–10	14
	Gould	? 53	56	35	3=241	86	—	22
22. *oliver*	Berry, 1914*b* ♀	? 40–35	105–77	74–57	2341 321=4 etc.	7	—	—
B. Group of *O. macropus.* (*a*) Sub-group of *O. macropus.* 1. *macropus* ♂♀	Brit. Mus.	35–115	32–53–96	20–41–75	1.2.3.4	79–84–91	10–11–13	12
2. *chromatus*	Heilprin	—	78	65	1.3.2.4	Sc. 86 very attenuated.	—	—
3. *taprobanensis*	Brit. Mus. ♀ type	20	40	? 33	1234	67	10	2·5
4. *ornatus*	Gould Berry, 1914*a*	68–24	76 (fig.) 83–104(?)	43 (fig.) 51–79	243=1 1234 etc.	? 90 88–85	— —	— 12–13
5. *medoria*	Brit. Mus.	29	55	?	1.2.3=4 ?	84	12	10
6. *machikii*	Brock	20	45	—	1.3.2.4.	77	—	—

* Calculated.

8. Web formula.	9. Web, depth.	10. Radula.	11. Hectocotylus, length of ligula.	12. Sculpture.	13. Colour.
BACDE	20–33	—	—	("Smooth.") Low simple warts and numerous pustules.	(*a*) Yellowish-brown, darker on dorsum. (*b*) White speckled with dark chromatophores occasionally forming dark maculae on dorsum. Two rows of larger chromatophores up the arms (Massy).
C.D.B.E.A.	28	—	Very minute ?	Obsolete simple warts. ? Originally low and close.	?
CB=D.EA C=D=EBA etc.	10–15	R=A_{3-4} 1L, variable. 2L, no entocone. 3L, slender, base small.	3·2–3·3	Scattered warts. A wart usually in centre of each light area.	Pattern of circular light patches on a purplish-red ground.
? Subequal.	15–25	—	6–5%, ? smaller.	Slightly warty.	Two rows of chromatophores up arms, large and small chromatophores on dorsum, small chromatophores on ventral surface.
DCEBA CDBEA "About equal all round" (Berry).	17 24, B.M. 33–25, Massy. 11–17(?), Berry.	R=A_{2-3} 1L, very high cusp, narrow base. 2L, no ectocone, no heel. 3L, thick.	0·4–1·4 5·5 Joubin, '94.	? No sculpture. Usually heavily wrinkled and with a rough scaly surface. A few dorsal cirrhi. Ocular cirrhi.	Warm ochreous red suffused and maculated with purple. An ocellus.
C>D>A>B>E	22 ? 20–16	R=A_{3-5} 2L, entocone present.	1·5	Numerous close rosette-like tubercles. Centre of rosette high.	?
? C=D=B.A.E	Under 25	—		Numerous low, rough, conical tubercles, the skin between smooth or finely papillose. No ocular cirrhi.	Dark slate; inner surface of suckers light brown sometimes shading to cream.
A.B.C.D.E.	11–16–25	R=A_3 2L, entocone and heel absent.	4·8–9·5–14	Fine warts tending to become granular.	Reddish.
—	? 17	—	—	Granular.	"Milky, blotched or speckled with ochre, sprinkled with brown."
? A=B=C.D.E	14	—	—	Smooth.	Buff with rough quincuncial pattern of purple chromatophores.
BACDE —	10–11 (?)	— —	— 1·1–3·8	"Coarsely reticulate-papillose," ovoid brachial "bullae." Papillae generally linear (Berry).	Deep orange with longitudinal buff stripes.
A=B=C=D.E ?	16	R=A_4 1L, base narrow, cusp high. 2L, no entocone, no heel.	—	Fine sparse granules, a few larger and coloured brown.	Pale ochreous brown with dark patches.
—	—	—	—	Finely granular.	Dark ochre, covered very closely with light and dark chromatophores.

		1. Dorsal length of mantle (mm.).	2. Width index.	3. Inter-ocular index.	4. Arms, formula.	5. Arms, length.	6. Gill-filaments.	7. Diameter of suckers.
(*b*) Sub-group of *O. leioderma.*								
1. *leioderma*	Berry ♀	? 25–40	? 100	? 77	1234	70–71	—	—
2. *tsugarensis*	Sasaki, 1920 ♂	? 29	100+	? 95	Subequal	? 80	9½	—
3. *longispadiceus*	Sasaki, '17, '20, ♂ U.S.N.M., ♀	65–42 43	94–81 100	94–73 88	123=4 —	78 84 80	10–11 9	♂ 24 23
C. Group of *O. aegina.*								
1. *aegina* ♂♀	Brit. Mus.	51–58	40–64	31–33	4321	77–71	7	7·7–11
	"Kagoshimensis" types	40–46	48–52	39–42	3421(?)	76	9	10
2. *areolatus*	Brit. Mus. Mus. Leiden Massy, '16 Appellöf, '86 Ortmann. Mus. Ac. N.S. Philadelphia (8)	25–52	43–76	32–52	3421 423=1 3214 34=21	68–78	10–12	♀ av. 9 ♂ ,, 22
3. *ocellatus*	Brit. Mus. Berry (1912*b*), Mus. Leiden	31–53(?)	83–94	50–69	3.2.4=1 4312 3=421	69–81	7 8	♀ av. 13 ♂ ,, 21
4. *pulcher*	Göttingen type ♀	17	47	—	43=21	70	—	—
5. *hardwickei* ?=*egina* (For *O. membranaceus*, see p. 50.)	Brit. Mus. ♀	22–32	43–50	37	3421 4231 4=31=2	70–75	8–7	8
D. Group of *O. pallida.*								
1. *pallida*	Brit. Mus. type ♂♀ Berry, 1918 ♂♀	45–100	68–104	39–68	4321	68–71–75	9–8	8–12
2. *californicus*	U.S.N.M. ♀ cotype	24	83	75	Irregular	71	[13]	[8]
	Berry, 1912*a* * (average of Nos. 1, 2 and 3)	72–80	77–84 "Slightly wider than long" (!)	63–65	2143 4213 etc.	71–77 * (Including No. 4)	—	—
3. *gilbertianus*	Berry, 1912*a* ♂ type No. 453	58 (fig.) 70 (calc.)	110 84	75 64	2.4.1.3 2.4=1.3 (table)	77 ,,	— —	Enlarged in ♂
4. *dofleini*	Wülker, 1913 ♂	130	69	50	2143 2134	75	—	—
E. Group of *O. tenuipulvinus.*								
1. *tenuipulvinus*	Sasaki, '20 ♂	19	100	? 95	R 1>2>3>4 L 2>3=1>4	85 ?	8	—

* Calculated.

8. Web formula.	9. Web, depth.	10. Radula.	11. Hectocotylus, length of ligula.	12. Sculpture.	13. Colour.
Sc. A=B=C>D>E	25+	—	—	Smooth; some short simple papillae. Ocular cirrhi.	Very pale grey buff suffused with purplish-brown.
See text.	? 25+	—	9	Smooth faint warts about the eyes.	Reddish-brown, three stripes on head.
" Broad " A=BCDE	20 25	— —	10 9	Roundish warts best developed above eyes.	Pale purplish-brown.
DECBA	22–30	R=A_4 1L, very long, cusp low. 2L, no entocone heel.	8	Smooth ?.	Very characteristic reticulation on arms and anastomosing lines on dorsum.
D=E"CBA	22	—	5·4–6·5	Coarse close polygonal warts.	Dirty olivaceous or brownish-grey, reticulate.
CDEBA C=D.E=B.A	20–33	R=A_1 1L, long and narrow.	4·4–13 (?)	Closely shagreened with fine or coarse warts.	Ocellus, interocular spot.
CDBEA, etc.	21–27	—	6·1–5·7	Warts coarser than in *areolatus* and often multifid and rosette-like.	Ocellus, interocular spot.
D=CEBA (subequal)	28	—	—	Smooth; three conical ocular cirrhi, four dorsal cirrhi arranged in a diamond pattern.	Dark greyish-brown marbled with darker brown. An ocellus.
C=D=E.B.A	25	R=A_{5-6} 1L, cusp high, long base. 2L, no entocone. 3L, slender.	—	Mainly smooth; a tract of low warts in mid-dorsal line.	Discoloured; reticulate pattern on web and arms.
Hoyle, " subequal." Berry, ? E>A "	24	R=A_4	9–12	Numerous close rosette-like tubercles, centre of rosettes low.	Pale purplish-grey.
A=B=CDE	22	—		Densely covered with large stellate papillae.	Livid pinkish-brown.
? B=C=D>A>E A<E	? 25	—	14–17	Ditto.	Ditto.
? B.=C=A>D>E B.C=A>D>E	? 21+	—	12 16	Numerous minute rough papillae; ocular cirrhi.	Deep brownish-claret-mottled with a darker shade above.
BCD>A>E	25	—	6·2	Wrinkled dorsally and with a few warts.	—
" Poorly developed, equal."	—	—	—	Finely tessellated with grooves and beset with tubercles.	—

		1. Dorsal length of mantle (mm.).	2. Width index.	3. Inter-ocular index.	4. Arms, formula.	5. Arms, length.	6. Gill-filaments.	7. Diameter of suckers.
F. Group of *O. fusiformis.*								
1. *fusiformis*	Brock Massy	45–67	26–35	26–32	1.2.4.3 2.1.3.4	72–79	—	8–5
2. *teuthoides*	Brit. Mus. ♀	16	37	26	1234	57	—	—
3. *amboinensis*	Göttingen Brock Joubin	17–18	41–44	—	3.2.4.1	76–75	—	—
G. Group of *O. deflippi.*								
1. *deflippi* ♂♀	Brit. Mus.	—	(*a*) 84–89 (*b*) 50–57	40–55–61	3.2.1.4	83–84–86	9–10	11
	Massy, '16A	—	46	34	—	83	—	0·9
2. *niveus* (*olim aculeatus*)	Paris, ? type Frankfurt, ♂♀ Orbigny, '40 Massy, '16A, ♂	17–40	111–45	62–48	4231 3241 2431 etc.	90–81 (see p. 141)	—	♂ 20
3. *filamentosus*	Brit. Mus., ♀ Orbigny Wülker, 1913, ♂	16	68	51	4321 3421	90–86	7 8	—
H. Group of *O. australis*								
1. *australis*	Brit. Mus. ♂♀ types Massy, '16A Berry, '18	22–33 *	86–81	62–73	3214 4213 3241 etc.	72–76	6–9	11–13
I. *Unclassified.*								
1. *furvus*	Gould	150(?)	61	38	Subequal	86	—	—
2. *filosus*	Howell	—	51	43	3=4.2.1	81 Filiform at end.	—	"Large."
3. *tehuelchus*	Orbigny	? 22	113	80	4.3=1.2 Subequal	80	—	—
4. *schultzei*	Hoyle Mus. Berlin (type)	50	96	?	2.3.4.1 3142	83	9	22
5. *patagonicus*	Lönnberg	115	95	60	1.2.3=4 2.1.3=4 Subequal	83	—	"Very large on middle of arm."
6. *pusillus*	Gould Hoyle, '04*a* (Radula and hect. only)	19 (fig.)	68	63	1.2.3.4 ? Sub-equal	74 (fig.) 66 (text)	—	—
7. *arborescens*	Hoyle, '04*b*, ♂ Brit. Mus., ♀	8–12	62–80	75–80	Subequal	73–66	5–6	—

* Calculated.

8. Web formula.	9. Web, depth.	10. Radula.	11. Hectocotylus, length of of ligula.	12. Sculpture.	13. Colour.
? Subequal (Massy).	20 (Massy	—	0·8	Fine close warts produced into cirrhi (?) on head; ventrally a network.	Yellowish-white ventrally, dorsally dark brown finely marbled with black.
Equal.	17	—	—	Smooth.	Pale yellow; pale red chromatophores anteriorly and dorsolaterally. A ring of these round anterior edge of mantle and a double row on arms.
Equal.	7–10	—	—	Smooth.	Uniformly clear ochreous; a mass of violet chromatophores between the eyes (Brock).
? A=B=C=DE	7–13	R unicuspid. (?) 2L = No. 3.	—	Probably smooth in adult; warts round eyes.	Pale, golden yellow; sometimes darkly maculate.
E>rest.	12	—	3·2		
? Subequal.	4–12	—	4–1·4	Papillae and cirrhi on web and dorsal mantle; ocular cirrhi.	Lesson, "white." Orbigny, "yellow-rose below." Massy, "lilac."
Subequal.	6–12	—	—	Smooth (Orbigny). Wrinkles and warts (Brit. Mus.), etc. Cf. Wülker.	Blackish above; inside of web white.
BDA=CE B=CDAE	33	R=A_2 1L, long base, cusp low. 2L, no entocone, low mesocone. 3L, broad base. (See p. 145.)	10·8	Thickly covered with small granular warts; * ocular cirrhi and enlarged warts on body.	Ochreous mottled and maculated with brown. Arms barred.
B>A Lateral sectors "extend much further than from above backwards."	Sc. 20	—	—	Smooth.	Ochreous, ? maculate black to ash colour, suckers white.
—	? 14–15	—	—	Smooth with "dorsal beards."	Reddish.
!	? 20–25 from fig.	—	—	Smooth.	Blackish-brown.
ABCDE BCADE	32 (?)	R=B 2L, no entocone. 3L, wide base.	2·4 No groove, a transverse pit.	Smooth.	Dull purple.
B>rest. E absent !	20	—	—	"Densely wrinkled."	Dark violet.
C=AB=D ? E	Sc. 33–30	R=B_4 1L, cusp very prominent. 2L, no entocone, no heel.	[8]	Smooth, no cirrhi.	Slate-coloured (dried).
C=D.B.A=E	33–50	R=A_2 1L, very deep, base triangular. 2L, no heel.	2·5	Branched papillae. See text p. 151.	Dull ochreous grey, circular and irregular dark purple markings.

* Warts coalesce to form ridges (Berry).

		1. Dorsal length of mantle (mm.).	2. Width index.	3. Inter-ocular index.	4. Arms, formula.	5. Arms, length.	6. Gill-filaments.	7. Diameter of suckers.
8. *chierchiae*	Jatta, '89 and '99 ♂♀	? 15	—	—	4321	62	—	—
9. *parvus*	U.S.N.M., ♀ Sasaki, '17 and '20	30	83	53	? 2341	77	? 4-6	16
10. *alatus* (? *Joubinia*)	Sasaki, '20	55 Ventral	—	—	1>2>3>4	80(?)	11	? 7-8
11. *validus*	Sasaki, '20	44	100+	? 95	1>2>3>4	66+	7½	—
12. *spinosus*	Sasaki, '20	? 23	—	95 ?	Subequal 2.3>1.4	64	10–11	"Small," ? 7%
	U.S.N.M., ♀	19	84	78	2341	73	9	7–9
13. *ochotensis*	Sasaki, '20 ♂♀	—	100+	81(?)	Subequal	75	? 9	Not enlarged
14. *inconspicuus*	Göttingen type ♂ Joubin, ♂	37–60	50–51	—	23=41 2413	78–75	—	—
15. *salutii* ♂♀	Brit. Mus., etc.	*c.* 40–50	50–51–52	44–47	More or less subequal.	75	9–10	5 ♀ Strikingly enlarged in ♂ (Naef).
16. *madokai* (= *pustulosus* Sasaki)	Sasaki, 1920 ♀	? 73	? 100	? 95	"1>2>3>=4" (Sasaki)	75	? 10–11	—
17. *hawaiiensis*	Eydoux and Souleyet	23 (from fig.)	78	69	2.1=3=4	76	—	—
18. *membranaceus*	Quoy & Gaimard Orbigny	17 (Orb.)	82 (Orb.)	82 (Orb.)	23=41	73	—	—
19. *bermudensis*	Brit. Mus., etc.	12	81	72	1.2.3.4	86	—	—
20. *joubini* ♀	Brit. Mus., etc.	16	75	62	2=3.4.1	67–69	—	6
21. *verrilli*	Verrill "*pictus*"	8	100	100	Subequal	66	—	—
22. sp. = *brevipes* Hoyle	Brit. Mus.	—	84	78	Subequal	48	10	—
22*a*. sp. (p. 164)	Brit. Mus.	—	53	60	2.3.4.1	70	—	—
23. sp. (p. 164)	Brit. Mus.	—	60	44	?	82	—	—
24. *superciliosus*	Quoy & Gaimard Orbigny Type	16(?)	59 (fig. Q. & G.)	50 (fig. Q. & G.)	2.4.3.1 (Orb.)	77 (Orb.)	—	—
25. *capensis*	Eydoux and Souleyet	5(?)	66(?)	66(?)	Subequal	41	—	—
26. *wolfi*	Frankfurt ♂ type	9–10	100	115	Subequal	65–6	—	—

8. Web formula.	9. Web, depth.	10. Radula.	11. Hectocotylus, length of ligula.	12. Sculpture.	13. Colour.
CDEBA	33	RA_3	8	Smooth.	Brown stripes on arms, head and mantle.
Subequal.	20	—	—	Uniformly covered with beady warts.	Dirty brownish-purple.
"Well developed."	23	—	5	Smooth.	—
Uniform.	25	—	—	Dorsally covered with stellate or rosette-like warts.	—
"Well developed."	32	—	—	Thickly and evenly beset with large spinous warts with stellar bases.	—
C=D=BA=E Subequal.	42	—	—		Maculate and reticulate with purple on dorsum only.
—	33–25	—	4	Smooth; a few warts.	—
Equal.	10–13	—	2·0 Brock. (?)4·3 Joubin.	Dorsally wrinkled and bearing characteristic warts.	Yellowish-brown; back and sides marbled with dark slate-grey.
C=B=DAE Wide membranes.	24	$R=A_4$ 2L, no entocone, heel weak.	14	Irregular warts.	Orange yellow; dark clouding, etc.
—	25	—	—	Sparsely covered with minute warts. Twenty large tubercles regularly arranged; ocular cirrhi.	Uniformly drab.
CBD=AE	? 20	—	—	Smooth, no cirrhi.	Bluish grey; grey-black chromatophores.
Subequal ?	? 12	—	—	Granular.	"Whitish" (Q. & G.).
? B.C=D=E	14	—	—	Probably smooth.	Yellow ochre with a pale sienna patch on back and head.
A=B=C=D=E	33–30	—	—	Probably smooth.	Discoloured.
? A=B=C=DE	25	—	—	Probably smooth.	Entirely covered with reddish-brown spots.
Subequal.	50	—	—	Smooth.	Spots on arms and mantle.
Subequal.	?	—	—	Smooth.	Discoloured.
D.C.B.E.A	12	—	—	? Warty.	Discoloured.
A=B=C=D=E (Type.)	19	—	—	Finely granular, small number of prominent warts.	"Almost white" (Q. & G.).
? Subequal.	Sc. 35	—	—	Smooth, no cirrhi.	Whitish; semi-transparent; spotted with red on back and arms.
C=DABE	? 15	—	10–11	Numerous isolated reddish papillae.	Dark wine-red with weak transition to violet.

		1. Dorsal length of mantle (mm.).	2. Width index.	3. Inter-ocular index.	4. Arms, formula.	5. Arms, length.	6. Gill-filaments.	7. Diameter of suckers.
27. *gardineri*	Hoyle, '05 ♂ Brit. Mus. ♂	12	75	82	4321 4=2.3=1	72–75	—	—
(ii) *Macroctopus.* 1. *maorum*	Brit. Mus. ♂	172–210	39–49	26–35	1.3.2=4	81–87	13–14	10–15
2. *communis*	Park	(Body and head) 325	—	—	Subequal 12=34	73	—	11
(iii) *Enteroctopus* 1. *megalocyathus*	Brit. Mus. ♂ Gould	200 34	80–66	36–70	1234	83–78	11	20–11
2. *membranaceus*	Rochebrune and Mabille	—	45	—	—	76	—	—
3. *eureka*	Brit. Mus., ♂ Hoyle, ♂	54 50	77 100	72 88	? 1234 1234 Subequal	81 79	— —	12 18
4. sp. (= *brucei*, Massy)	Brit. Mus. ♀	11	86	68	1234	78	—	9
(iv) *Tritaxeopus. cornutus*	Owen, '84 ? ♀	? 116	69	58	3241	83	—	3-Serial
(v) *Macrotritopus.* 1. *equivocus*	Verrill, '84*a* ? ♀	11	63	59	3.1.=2 3>2,×2	79	—	—
2. *scorpio*	Berry, 1920 ? ♀	(?) 6	64	64	3241 3>2,×2+	79		
3. *bandensis*	Brit. Mus. type ♀ Massy, '16A ♀ Appellöf '98	6–7 ? 30	83-78	100–92	321=4 3421 3124 3>4 ∞2 ×1·2–1·6	80–89	—	—
4. *kempi*	Brit. Mus. ♀ type	10	80–95	57–60	3241 3>1·5–0·8	72–78	—	—
5. *elegans*	Göttingen (type)	21	38	—	3241 3>2,1·5	83	—	? 9
2. *Cistopus indicus*	Brit. Mus., ♂ Orbigny, type	46–70	52–87	34–64	1243	84–87	10–11	13–17
3. *Pinnoctopus* 1. *cordiformis*	Quoy & Gaimard, 1832	175 (?)	69 (fig.)	—	Sub-equal 1.4>2.3	Sc. 81	—	—
2. *kermadecensis*	Berry, 1916 ♀	43	46	39	1234 123=4	72 (?)	—	—

8. Web formula.	9. Web, depth.	10. Radula.	11. Hectocotylus, length of ligula.	12. Sculpture.	13. Colour.
A=B=C=D.E (?)	25–35 (?)	—	3·2	Smooth.	Dull yellowish-grey sprinkled with small chromatophores.
ABCDE	18	R=A_3 1L, large cusp. 2L, no entocone, heel present. 3L, straight, tips reflected.	6·2–8	Smooth (?), faint trace of low broad warts.	Pale ochre or grey marbled greyish-purple.
—	—	—	"Long."	"Smooth."	"Dark steel grey blotched irregularly with pale grey."
? A=B=C=D.E	23–15	RA_{3-5} 1L, low cusp. 2L, no entocone, heel weak. 3L, heavy and curved. M. degenerate ?	4·8–8·6	Smooth.	See text.
Extensive.	—	—	—	Smooth.	Deep violet; arms marbled.
CBD=EA CBDA=E	23 28	R=A_3 ? 1L, see text. 2L, short base, low heavy cusp.	6·9 6·3	Smooth ? Smooth ?	Deep violet; arms and body marbled (discoloured).
A=B=C=D.E	21	R unicuspid 1L, low, coarse cusp. 2L, narrow base. M. not degenerate.	—	Rough.	—
—	? 10+	—	—	Scattered warts on dorsum.	Dullish-pink.
(?) Equal.	(?) 14	—	—	Smooth.	See text
Unequal.	(?) 10	—	—	Papillate.	See text.
Equal (Massy).	11	—	—	Warts on back and sides; ocular cirrhi (?).	See text.
CB=DA=E	16	—	—	Smooth.	See text.
Subequal.	6	—	—	Smooth.	See text.
ABCDE (C=BAED) etc.	13–18	R=A, A tricuspid, no seriation. See text.	See text.	Fine low widely-spaced warts.	? Dull purple.
? Subequal.	16–14	—	—	Tuberculate.	Brownish-red, pale below, head and arms with light blue lunules; fins bordered with bluish-green.
? A>B>C>D>E	16	—	—	Smooth; a few weak dorsal and ocular papillae.	Dull grey-brown streaked and mottled with slate colour.

		1. Dorsal length of mantle (mm.).	2. Width index.	3. Inter-ocular index.	4. Arms, formula.	5. Arms, length.	6. Gill-filaments.	7. Diameter of Suckers.
4. *Joubinia*								
1. *fontaniana*	Brit. Mus. ♂♀ average	22–37	96	67	Subequal or 3=241	72–78	9–10	14
2. *campbelli*	Brit. Mus. ♂ type	28	85	71	Subequal or 3214	78	10	21
5. *Scaeurgus unicirrhus*	Brit. Mus. ♂♀	56–13	70–90	50–60	Subequal	71–81	13–14	9–10
	Berry, 1914*a* (204–207)	—	—	—	—	69–70	—	8·5–10
6. *Macrochlaena winckworthi*	Brit. Mus. ♂	35	48	48	342=1 41=2 ? 3 Subequal	53	9	12
7. *Pteroctopus tetracirrhus*	Brit. Mus. ♂♀	60–43	91–83	75–76	? Sub-equal	78–81	9–10	5–5·8
8. *Paroctopus*								
1. *digueti*	Paris Type ♂	28	77	47	Subequal	75–70	6–7	8 ♀ 23 ♂
2. *apollyon*	Berry, 1912*a* (8)	23–75(?)	52–100	49–86	2134	70–78	—	—
	Verrill	229	61	28	2143 etc.	81	—	7·8
3. *hongkongensis*	Brit. Mus., ♂, Type	16–115	72–100	50–72	1234	75–85	10–10	6·2–13
	Massy				2143			
	Leipzig, ♂				1243			
	Joubin, 1898, ♂(?)				etc.			
4. *yendoi*	U.S.N.M., ♀	40	100	77	1342	82	11	10
	Sasaki (1920), ♂♀	54–58	—	—	1>2>3=4	80	10–12	—
5. *conispadiceus*	U.S.N.M., ♂	70	92	61	2143	79	10–10	15
	Sasaki (*l.c.* '17), ♂	—	—	Sc. 50	1=2=3>4	75	10–12	—
9. *Hapalochlaena*								
1. *maculosa*	Brit. Mus. ♂♀	19–45	53–90	46–69	3241	68–75	6	6–7·6
	Göttingen ♂ type				3421			
	Leipzig, etc.							
2. *lunulata*	Brit. Mus. ♂♀	—	70–93	57–73	432=1 4=321	74–69	9–7	8–5
	Type ♀ fig.	—	71±	44±	—	—	—	—
	Orbigny text	—	100	—	4321	65	—	—

8. Web formula.	9. Web, depth.	10. Radula.	11. Hectocotylus, length of ligula.	12. Sculpture.	13. Colour.
A=B=C=D.E	23	R=B_{5-6} 1L, ? bicuspid. 2L, entocone, mesocone low.	6+	Warty.	Reddish-purple.
Equal.	28	—	8·5	? Rougher than *fontaniana*.	Reddish-brown covered by an olivaceous bloom.
B=C.A=D.E.	29–21	—	10–8	Numerous conical warts (mainly single).	Greenish, maculate brown.
C.B=D=EA	33	R=A_3 2L, mesocone median, no entocone.	See text.	Smooth.	Pale greyish-purple.
ABCD=E A=B.C=D=E.	34–39	—	4–3	Low broad warts.	Yellow with a greenish iridescence on the ventral surface (Jatta).
DC=EA=B	24	—	7·8	Granular, granules sometimes in anastomosing lines.	Yellowish, maculated or uniformly covered with purple (in alcohol). Rose white with reddish maculae (? in life).
A>E D.C=BAE or EA	— 23	— —	11–2·8 13–9	Numerous papilliform tubercles with stellate bases and many irregular wrinkles; ocular cirrhi; bilaterally arranged dorsal cirrhi.	Dull brownish or purple heavily maculate.
B=C=DAE C=D=BAE	23–6	R=A_4 1L, very narrow base. 2L, no entocone.	11–20	Small, simple granules and short irregular rugae; ocular cirrhi.	? Brownish-purple.
A=B.C.D=E "Broadest between ventral arms."	25	—	6–7	Beset with roundish warts.	Pale brown.
BCADE (subequal)	30	—	12 20–16	Mainly smooth; a few warts round head; ocular cirrhi.	—
Subequal.	20–48	R=A_2 1L, wide base. 2L, very low cusp. 3L, very slender.	4·6–10	Rugose or with low close warts.	See text.
Subequal.	40	R=A_2 1L, very weak cusp. 2L, no entocone, heel. Marginals ? degenerate.	—	Tuberculate or smooth; ? gelatinous.	See text.
— —	25 ±	— —	— —	— —	—

XI. SYSTEMATIC.

Genus I. **Octopus,** Lamarck, 1798.

Octopodinae with normal ink sac and moderate web. The web is usually bilateral in the adult and C or D is usually deepest. The penial diverticle is single. The hectocotylus is dextral, usually short; the eggs (so far as known) are small (under 5 mm. long). No velar pouches or "fins." The mantle is aperture wide.

Type of the genus.—Octopus vulgaris, Lamarck, 1798.

Linné (1758, p. 658) placed an octopus in his genus *Sepia*, naming it *Sepia octopodia*. The identity of this form as an Octopod is established by Linné's citations (*e.g.* Jonstonus (1657, t. 1, f. 1). Linné did not designate the type of his "*Sepia*." This was accomplished in 1910 by Hoyle, *Sepia officinalis* (the Common Cuttlefish) being thus designated. At the same time Hoyle designated *Octopus vulgaris* as the type of *Octopus*, Lamarck. *Sepia* (with *Sepia officinalis* as type) was placed on the "Official List of Genera" by the International Commission on Zoological Nomenclature (Opinion 94, pp. 12–13) Any ambiguity as to the right generic name of the true Octopods is thus disposed of.

The definition of the Linnean genus *Sepia* ["Brachia *sex* interius adspersa cotyledonibus (praeter 2 Tentacula longiora quibusdam). Os inter brachia, terminale. Oculi ? infra tentacula versus corpus. Corpus vagina excipiens pectus"] is very defective, and the words "Brachia sex . . . praeter 2 tentacula" ("six arms in addition to two *tentacles*") are applicable neither to our *Sepia* nor our *Octopus*. Moreover, *Sepia octopodia* ("tentaculis nullis") by his definition must have six arms only! Apart from this error (obviously accidental because the name *octopodia* is given) the Linnean *Sepia* is a composite group containing "*officinalis*," "*media*," "*Loligo*" and "*Sepiola*," forms recognizable from his citations as our *Sepiola*, *Loligo*, etc. Gmelin (1790, p. 3149) altered Linné's *octopodia* to *octopus*; but he contributed nothing to a better arrangement of the diverse elements contained in Linné's *Sepia*. The relationship and names of the Octopus, Cuttlefish, etc., were regularized by Lamarck (1798, p. 130; 1799 p. 1), who distinguished Sepia (with *Sepia officinalis* and *tuberculata*) from Octopus (with *vulgaris*, *granulatus*, *cirrhosus* and *moschatus*). None of the constituent species are designated by him as types of these genera; but his remarks on p. 2 of his Mémoire (1799) and the nature of his definitions leave no doubt in the mind as to the relationship and character of the groups in question, and we now have no hesitation in accepting *Octopus* as the right name for the group in which our common Octopus is to be placed. The choice between Lamarck's *Octopus* and *Polypus* of Schneider, 1784 (the latter name being recommended by Hoyle (1901) and freely used by many writers since that date) is, I think, quite easy. Schneider (1784, p. 116) obviously attempted to formulate definitions of certain groups of Octopods and he plainly grasped the distinction between e.g. *Eledone* and his *Polypus*. It may, therefore, be

felt that such groups were equivalent to genera, though he actually calls them *species*. But (1) Schneider does not use binominal nomenclature and (2) his categories are not those accepted in traditional systematic practice (cf. Grimpe, 1920, p. 206). If evidence is wanted as to the ambiguous status of his groups "*Polypus*," etc., it is forthcoming, as Mr. J. R. le B. Tomlin has pointed out to me, on p. 113 of his work, where his "*Teuthis*" is identified with Linné's *media* (*Sepia*)! It is thus quite impossible to accept the names proposed in this work.

Subgenus i. **Octopus,** Lamarck (Orbigny).

The arms are not conspicuously different in length. There are two rows of suckers. The penial diverticle is short. Suckers unmodified in female. Gill filaments rarely exceed eleven.

Type of the subgenus.—Octopus vulgaris, Lamarck, 1798.

Lamarck's *Octopus* was subdivided by Orbigny (1835, p. 8) into two subgenera, *Philonexis* and *Octopus* (s.s.). Orbigny's subgenus is here revived after many years of neglect.

A. Group of **Octopus vulgaris.**

Octopus (Octopus) vulgaris, Lamarck.

(Plate I, fig. 1; text-figs. 6, 7.)

Not *Sepia octopodia*, Linné (1758, p. 658), Fabricius (1780, p. 360 [? = *Bathypolypus arcticus*]) [Auctt.]; ? *Sepia octopus*, Gmelin (1791, p. 3149); *Octopus vulgaris*, Lamarck (1798, p. 130); "le poulpe commun," Montfort (1805, p. 113, figs.); *Sepia octopus*, Bosc (1802, p. 68); *Sepia octopodia*, Cuvier (1817*a*, p. 363), *id.* (1817*b*, p. 2); *Octopus vulgaris*, Carus (1824, p. 319, Pl. XXXI), Blainville (1825, p. 365, Pl. II, fig. 1), *id.* (1826, p. 188); ? *Octopus brevitentaculatus*, Blainville (*l.c.*, p. 187); *Octopus vulgaris*, Payraudeau (1826, p. 172), Savigny (1826, p. 9, fig. 1), Risso (1826, p. 3), Orbigny and Férussac (1826, p. 142), Ehrenberg (1828, *a'*), Sangiovanni (1829, p. 321), Wagner (1829, p. 387), delle Chiaje (1830, pp. 40, 55, Pl. LVI, fig. 1); *Sepia octopodia*, Oken (1835, p. 536); *Octopus vulgaris*, Philippi (1836, p. 240), Rang (1837, p. 62, fig.), Férussac and Orbigny (1840, p. 26, Pl. 2, etc.); *Octopus vulgaris*, Orbigny (1841, p. 11, Pl. 1, fig. 1 (as var. *americanus*)); *Octopus vulgaris*, delle Chiaje (1841, p. 2 and *passim* in anatomical section (p. 13)), *id.* (1841*a*, p. 65), Cantraine (1841, p. 18), Krauss (1848, p. 132), Gray (1849, p. 6); *Octopus cassiopeia*, *id.* (*l.c.*, p. 9); *Octopus vulgaris*, Vérany (1851, p. 16, Pl. 8), Forbes and Hanley (1853, p. 209, Pl. NNN, fig. 2), Aucapitaine (1863, p. 290), Fischer (1867, p. 12), Jeffreys (1869, p. 144); ? *Octopus troscheli*, Tozzetti (1869, p. 588); *Octopus vulgaris*, *id.* (*l.c.*, p. 587), Lee (1875 *passim*); ? *Octopus americanus*, Guppy (1877, p. 136); *Octopus octopodia*, Tryon (1879, p. 113, Pls. 23–24); *Octopus vulgaris*, Fischer (in Tryon, *l.c.*, pp. 62, 64), Stossich (1880, p. 157), (?) Verrill (1880*a*, p. 253), Ninni (1884, pp. 159, 161), Hoyle (1886, p. 6, etc.), Appellöf (1886, p. 7), (?) Jatta (1889, p. 64), Ortmann (1888, p. 642), Kolombatovič (1890, p. 7), Norman (1890, p. 466), Carus (1890, p. 459), Goodrich (1896, p. 19), Jatta (1896, p. 212, Pl. 4, etc.), Lönnberg (1896, p. 706), Joubin (1900, p. 33); *Polypus vulgaris*, Hoyle (1901, p. 1); *Octopus vulgaris*, Marchand (1906, p. 753, 1907, p. 311); *Polypus*

vulgaris, Hoyle (1907*a*, p. 35), Pfeffer (1908, p. 20, figs. 11–13); *Octopus vulgaris*, Zimmerman (1907, p. 293), Joubin and Fischer (1907, p. 322), Joubin (1907*a*, p. 48), Leidenfrost (1908, p. 160), Lo Bianco (1909, p. 650); *Polypus vulgaris*, Massy (1909, p. 1), Wülker (1910, p. 5), Berry (1912*b*, p. 386), Grimpe (1913, p. 531); *Octopus vulgaris*, Coen (1914, p. 1); *Polypus vulgaris*, Thiele (1915, p. 487); *Octopus vulgaris*, Tanner (1916, p. 24), Grimpe (1918, p. 593); *Polypus vulgaris*, Wülker (1920, p. 56); *Octopus vulgaris*, Joubin (1920, p. 32), Monticelli (1921, p. 187), Naef (1921, p. 538), *id.* (1922, p. 288); *Polypus vulgaris*, Belcher (1922, p. 312); *Octopus vulgaris*, Naef (1923, p. 695), Joubin (1924, p. 10), Robson (1925, p. 106), *id.* (1926, p. 185), Grimpe (1925, p. 13), Degner (1925, p. 78), Massy (1928, p. 26); *Polypus vulgaris*, Boone (1928, p. 16); *Octopus octopodia*, Winckworth (1928, p. 49).

Type specimen.—Not traced.

Specimens examined.

(*a*) In Brit. Mus.

One specimen (? sex) from Dover : 70.10.1.1. One (♀) from Brighton : 1928.4.15.1. One (♂) from Plymouth : 1927.2.10.1. One (♀) from Falmouth : 1927.3.9.2. One (♀) from " English Coast " : 1927.3.9.1. One (♂) from " British Coast " : 1928.4.15.2. One (♂) from " English Coast " : 49.5.16.22. One (♀) from Guernsey : 1928.4.15.3. One (♀) from Guernsey : 58.5.28.1. Three (♂♂♀) from Naples : 48.5.21.337–9. One (♂) from Naples : 48.5.21.346. One (♂) from " Mediterranean " : 68.6.8.51. One (♀) from Rabat, Morocco : 1928.4.15.4. One (♀) from Pt. Etienne, Rio d'Oro : 1928.4.15.5. One (♀) from ? Mediterranean : 68.3.6.65. One (♂) from Lanzerote : 60.5.4.3. Six (2♂, 4♀) from unknown localities : 68.6.8.4 : 70.1.20.1 and 6 : 74.2.26.1 : 1928.4.15.5 : 1928.4.15.6. One (♂) from Madeira : 53.9.12.2. One (♂) from Marseilles : 1928.4.15.6 (type of *O. cassiopeia*, Gray).

(*b*) In M.H.N., Paris.

One specimen from Boulogne. Three specimens from Marseilles.

(*c*) In U.M., Jena.

One specimen from Algeciras. One from Corsica. One from Rovigno. One from Granville. One from Messina.

(*d*) In Z.M., Berlin.

One specimen (50234) (♀) from Altatea, Mexico (? *rugosus*). One (♀) specimen from Mexico. One (♂) from St. Paul Island (Ind. Ocean) (Thiele, 1921). One (♂) from Simon's Town, South Africa (*id. ib.*). One (♀) from Cyrenaica (? *macropus*). One (38941) from Cape Town. One (♂) from Heligoland. One from Bird Key Reef, Tortugas (West Ind. Reise, 1907). One (45329) (♀) from Haiti.

Distribution.—The Common Octopus has had a wide distribution recorded outside the Mediterranean and N.E. Atlantic. It was obtained from Mauritius, India, and Timor in the Indo-Pacific Region, and from Haiti, Cuba and Bahia in American waters by Orbigny (1840, p. 30). Krauss (1848, p. 132) reported it from S. Africa, and in 1886 Hoyle (1886, p. 214 and foll.) placed it in ten out of his seventeen zoogeographical regions. The record from Greenland (Fabricius, *l.c.*, p. 360, as *Sepia octopodia*, L.) is to be regarded as erroneous (see Posselt, 1898, p. 229) as later investigation shows that this species does not penetrate into cold

water. More recently it has been recorded from Japan (Ortmann (1888), Appellöf (1886), Wülker (1910), Berry (1912*b*)), the Andaman Islands (Goodrich (1896)), the Red Sea (Wülker (1920)), South Africa (Thiele (1915)), Australia (Cox (1882)), and the Southern Ocean (St. Paul, see p. 58). Of recent American records there are the rather dubious ones of Verrill (1880, p. 253) and Jatta (1889, p. 64, Payta (!)), and statements by Boon (1928, p. 16) and Calkins (1878, p. 232). Heilprin (1888, p. 324) speaks of "the common West Indian *Octopus vulgaris*." There are no satisfactory records of the species in the S.W. Atlantic and the Pacific (except the Japanese records cited above). It should be particularly noted that in comprehensive faunal lists published in recent years it is not cited in that of Massy (1916*a*, Indian Ocean), Winckworth (1926, Indian Ocean), Joubin (1894, Indo-Malaysia), Robson (1924, South Africa), and Massy (1925–6, South Africa). In European and adjacent seas it is of frequent occurrence and ranges from the Aegean to Mauritania, the Azores, N.W. Ireland and the English Coast. The records from Scotland [Firth of Forth (Forbes and Hanley, 1853, p. 210), Lamlash, Arran (Jeffreys, 1869, p. 144)] are questioned by Norman (1890, p. 466) and Grimpe (1925, p. 14). From the analysis of records made by the latter (*l.c.*) it would seem that the species does not pass further north than Heligoland in the North Sea. On the American side of the Atlantic the Bermudas may be the most northerly point of its occurrence (33° N.). It is thus limited in its northward distribution by the isotherm of 22° C.;* and like most of its relatives it is a species of warm and temperate waters. The island of St. Paul (40° S.) appears to be the most southern limit of its distribution. I have had very little opportunity of verifying personally the records of its occurrence outside the Mediterranean and N.E. Atlantic. The specimen from the island of St. Paul and one from S. Africa (Thiele, 1915) both in the Berlin Museum, are correctly assigned to this species. Otherwise there are no descriptions full enough to enable me to examine critically the identifications on which exotic records are based. Berry (1912*b*, p. 387) gives a detailed description of two Japanese examples. He does not, however, describe the web in detail, nor the sculpture, shape of penis, etc. He says of the specimens: "as I have no European specimens of *Polypus vulgaris* available for comparison I cannot feel personally certain that the following specimens are correctly referred to this species; but I think little doubt exists that they are conspecific *with the form so identified by the various other writers on Japanese Cephalopods*." He notes as *vulgaris*-like the lateral arms, which are notably larger than the others, the minute hectocotylus, reticulate surface (?) and reddish-grey colour. I have analysed the figures he gives and in seven characters both specimens are within the range of European forms, though in isolated features one or the other specimen exhibits extreme phases of variation. Subject to the limitations suggested above, Berry's data indicate that he had specimens of genuine *Octopus vulgaris*, and I am inclined to believe that the species has the wide range which has been attributed to it.

* The records of Octopods on the east coast of North America are surprisingly few. If the Bermudas are actually the most northerly point of the range of *Octopus vulgaris* on the west side of the Atlantic (Heilprin's record (*l.c.*) is vague), it follows that there is a curious disparity in its northern distributional limit on the two sides of the Atlantic (W. side, isotherm of 22° C., E. side isotherm of 11–10°). It may be found, however, that *Octopus vulgaris* ranges further north on the American coast.

Vertical distribution.—The range in depth of this species is very slight. It is a strictly littoral form and there are few records of its occurrence over 100 fathoms (the maximum depth recorded being 220 fathoms (Holt, 1892, p. 246), though Joubin (1900, p. 33) states that specimens were taken in a net in an offshore station over 748–1262 metres (see pp. 19–20). The station was in 47° 10′ N., 8° 08′ W. at a very considerable distance from land. If the record is accurate these specimens were either on the bottom at a very exceptional depth for the species or swimming far from land, again an exceptional feature.

Description.—The variation of fifteen organs and dimensions is given on p. 24.

(*a*) The body is variable in shape, but is usually broadly oval. The head is narrower than the body. The arms are in the order 3.2.4.1. (3.4.2.1. being a common alternative) and are on an average 78% of the total length. The suckers usually attain a maximum diameter of 13% of the mantle-length. The web has an average index of 20 and may be

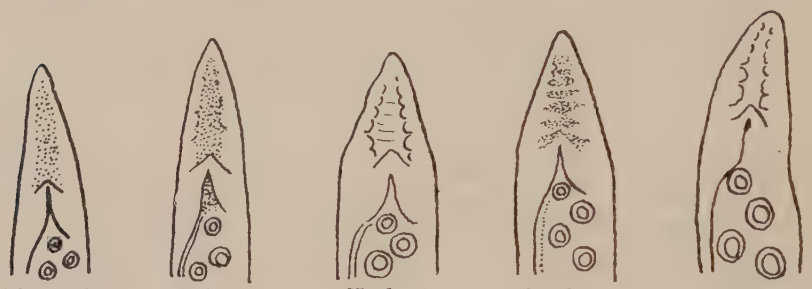


Fig. 6.—*Octopus vulgaris.* × *c.* 3. Variation in hectocotylus.

regarded as shallow. Its formula is CDBEA or CDEBA, but it is very variable. The funnel-organ is regularly **W** shaped. The radula usually has a rhachidian tooth with formula B 2–6; the cusp of the first lateral is low and the entocone of the second lateral is usually present. The third lateral is broad and moderately curved. The ligula of the hectocotylized arm is minute, averaging 4·4% of the arm. The skin is covered in life with close, irregular and usually large warts, which, when fully erect, produce an extremely rough surface. In preserved specimens these tend to be lower and more obscure. The colour in life is usually a rich yellow brown in the dorsal region, the warm tone is often increased to a reddish or orange-brown hue, and there may be an irregular pattern of dark and light yellow spots and blotches. Preserved specimens are usually greyish-green in colour.

(*b*) Owing, I presume, to the fact that this species is rarely found in large numbers there is no very complete account of its anatomy. The early writers (Cuvier, Delle Chiaje and Orbigny) have given good descriptions; but there is no modern comprehensive account other than that of Meyer (1912). Jatta (1896) [external parts, radula, mandibles, "stylets," etc.]), Marchand (1907, 1913) [♂ genitalia, spermatophores], Grimpe (1913) [vascular system] and Robson (1925, 1926*b*, 1928*d* [radula, pallial septum] have described and figured isolated structures in detail. For a

bibliography of papers on the structure and function of the branchial glands, white body and branchial hearts see Robson (1926*a*, p. 1342). The development is described by Naef (1928).

Maximum size.—See p. 62.

Habits.—These are fully discussed in the Introduction (p. 19).

Variation.—A study of variation in examples of this species is given in Part V. It will be seen from those data that in the majority of structures and parts examined the amount of variation is very considerable. We cannot at present come to a conclusion as to whether any definite varieties or races of this species may be distinguished. In spite of the frequency with which it has been recorded *O. vulgaris* is very imperfectly known from the systematic point of view. Few examples have been fully described, and we have no information as to the variation

Fig. 7.—*Octopus vulgaris.* Penis.

within the population of a given circumscribed area. The number of specimens at my disposal makes it impossible to ascertain if there are any significant differences, *e.g.* between Northern and Mediterranean forms. A comparison made between five British and five Mediterranean specimens showed that there is very little difference between the two groups; but, as the two sets were of different sizes and the sexes were differently represented among them, the comparison has little value. The only difference to which I attach any importance is that between the hectocotyli. In the Mediterranean forms that organ is provided with "cheeks" and in the British specimens these structures are absent (cf. Winckworth, 1928). Fischer (1867, p. 12) comments on the peculiarly large size attained by forms from the English Channel; but little importance is to be attached to this observation. The maximum size attained by the species is not easy to ascertain. Vérany (1851) mentions one which measured three metres in length, but does not say if this was the total span or the length of the arms and body. If the latter is indicated the span would be about sixteen feet, if the former, the span would be between nine and ten feet. Hanley (in Lee, *l.c.*, p. 32) states that at Leghorn forms were known with arms at least four feet long. In short, I am inclined to believe that a span of ten feet would be the maximum

attained by this species. Neither Jatta (*l.c.*) nor Naef (*l.c.*) gives maximum figures in length. They seem to regard twenty-five kilograms as the maximum weight. This was the weight of Vérany's specimen.

From a study of the tables on p. 42 it will be seen that this form has many features in common with *Octopus macropus* and *Octopus rugosus*. Variant individuals are sometimes found which are difficult to assign with any certainty to one or another of these forms. Particularly interesting are the two specimens from Haiti and Mexico (Z.M., Berlin, see p. 58), which, although *vulgaris*-like in general build, have a highly interesting and striking sculpture. This is certainly quite unlike that of any *vulgaris* I have ever seen, and is more like the rosette pattern occasionally found in *O. rugosus*. The specimen from Haiti has arms very short for *vulgaris*, which increases its resemblance to *rugosus*; the Mexican specimen has very long arms.

Remarks.—The specific name *vulgaris* proposed by Lamarck must be retained for the Common Octopus. It has been occasionally suggested that Linné's *octopodia* is the right name to be applied to this form, and Tryon (*l.c.*, p. 113) and Winckworth (1928, p. 49) have employed it as such. I am, however, indebted to Dr. Nils Odhner of the Riksmuseum, Stockholm, for a report and photograph of the type of "*Sepia octopodia*" which is now revealed unmistakably as an *Eledone* (Plate I, fig. 1).* The specific name *octopodia* is therefore inapplicable to the Common Octopus. It should be pointed out at the same time that Lamarck's type of *vulgaris* cannot be traced, and that from his description our Common Octopus would hardly be recognizable, were it not for his remark that it is the largest Octopod known (sc.) in European waters. Indeed, it was not until Orbigny's full and well-illustrated description (1840) was published that *Octopus vulgaris* became defined with any precision and delimited from *Octopus rugosus* and *Octopus macropus*. Gmelin's *Sepia octopus* (*l.c.*, No. 296, 1) has some claim to consideration. "Brachiis . . . verrucis sessilibus alternis in 2 series digestis" avoids confusion with *Eledone* (one row of suckers); but, as the species is said to range from the Mediterranean and Red Sea to Greenland (cf. p. 58), it is clear that Gmelin's *Sepia octopus* included forms of *Bathypolypus*. His specific name therefore cannot be given preference over *vulgaris*. Grimpe's (1925, p. 13) inclusion in his synonymy of this species of "*Octopodia polypus*, Schneider (1784, p. 116–17)," seems to me, with deference to Dr. Grimpe's opinion, quite unjustifiable. On the pages cited there is only one reference to the name *Octopodia* ("Die neuern Griechen nennen ihn ὀκτάπους oder im Diminutiv ὀκταπόδια"). This cannot possibly be interpreted as a proposal of the generic name *Octopodia*. Nor can I understand Dr. Grimpe's opinion ("Den gebräuchlichen Nomenklaturregeln nach müsste die Art [*O. vulgaris*] eigentlich richtig '*Octopus polypus*,' Schneider, heissen"). As already pointed out, Schneider's categories *Polypus*, *Moschites* are non-Linnean. Though he certainly calls them "species," they cannot pass as species in the Linnean sense.

* After this passage was printed Dr. Odhner informs me that this Linnean specimen originally believed to be the type is more probably a syntype and that Linné also used a true *Octopus* obtained from Hasselquist. If the identity of the type specimen or specimens of *octopodia* is uncertain there is a well-founded suspicion that Linné used members of two different genera as types, just as he cites Belon (fig. 332, = *Eledone*) and Rondelet (p. 513, = *Octopus*).

Octopus (Octopus) rugosus (Bosc).

(Plate II, fig. 3; text-figs. 8–9.)

Sepia rugosa, Bosc (1792, p. 24, tab. 5, figs. 1, 2); *Octopus granulatus*, Lamarck (1798, p. 130); *Sepia granulata*, Bosc (1802*a*, p. 47); *Octopus Backerii*, Orbigny (1826, p. 144); ? *Octopus tuberculatus*, Blainville (1826, p. 187); *Octopus americanus*, de Montfort, *id.* (*ib.*, p. 189); (?) *Octopus tuberculatus*, Risso (1826, p. 3), Orbigny (1840, p. 38, Pls. 21, 23); *Octopus rugosus*, *id.* (*ib.*, p. 45, Pls. 6, 23); *Octopus tuberculatus*, *id.* (1841, p. 15); *Octopus rugosus*, *id.* (*ib.*, p. 18); ? *Octopus vulgaris*, var. *americanus*, *id.* (*ib.*, Pl. 1, fig. 1); *Octopus geryonea*, Gray (1849, p. 7); *Octopus rugosus*, Gray (1849, p. 8); *Octopus eudora*, *id.* (*ib.*, p. 9); ? *Octopus favonia*, *id.* (*ib.*, p. 9); *Octopus tuberculatus*, *id.* (*ib.*, p. 12); ? *Octopus polyzenia*, *id.* (*ib.*, p. 13); *Octopus tuberculatus*, Targioni Tozzetti (1869, p. 588); ? *Octopus incertus*, *id.* (*ib.*, p. 589); ? *Octopus rugosus*, Verrill (1880*b*, p. 368); *Octopus tuberculatus*, Blv. ? *id.* (1883, p. 111); *Octopus polyzenia*, Smith (1884, p. 34, Pl. IV, figs. A–A3); ? *Octopus duplex*, Hoyle (1885, p. 226), *id.* (1886, p. 90, Pl. VII, fig. 5); ? *Octopus vitiensis*, Hoyle (1885, p. 226), *id.* (1886, p. 84, Pl. VII, figs. 6–8); *Octopus tuberculatus*, *id.* (*ib.*, p. 78); *Octopus occidentalis*, *id.* (*ib.*, p. 77); *Octopus granulatus*, *id.* (*ib.*, p. 80); ? *Octopus globosus*, Appellöf (1886, p. 7, Pl. 1, figs. 4–5); (?) *Octopus granulatus*, Jatta (1889, p. 64); (?) *Octopus tuberculatus*, nec Risso nec D. Ch., Carus (1890, p. 460); *Octopus rugosus*, Ortmann (1891, p. 669); *Octopus granulatus*, Brazier (1892, p. 4); *Octopus tuberculatus*, Fra Piero (1894, p. 270); *Octopus granulatus*, Goodrich (1896, p. 19); *Octopus tuberculatus*, Lönnberg (1896, p. 706); *Octopus rugosus*, Joubin (1897*a*, p. 99); *Octopus granulatus* var. *rugosa*, Joubin (1898, p. 22); *Polypus granulatus*, Hoyle (1904*b*, p. 195); ? *Polypus occidentalis*, *id.* (1904*a*, p. 14); *Polypus granulatus*, *id.* (1907*a*, p. 36); Wülker (1910, p. 5); *Octopus granulatus*, Weindl (1912, p. 270); *Polypus granulatus*, Thiele (1915, p. 487); *Polypus rugosus*, Massy (1916*a*, p. 189), *ead.* (1916*b*, p. 147, figs. 5–6); *Polypus occidentalis*, *ead.* (*l.c.*, p. 148, figs. 7–8); *Polypus granulatus*, Wülker (1920, p. 49); *Octopus tuberculatus*, Pallary (1920, p. 17); *Polypus granulatus*, Robson (1921, p. 440); *Polypus granulatus*, Thiele (1921, p. 436); *Octopus tuberculatus*, Odhner (1922, p. 221); *Polypus rugosus*, Robson (1924, p. 669, fig. 42); *Polypus granulatus*, Massy (1925, p. 222); *Octopus rugosus* and *granulatus*, Robson (1925, pp. 104–5); *Octopus rugosus*, Robson (1926*b*, p. 188, fig. 17), Winckworth (1926, p. 324), Peile (1926, p. 98); *Polypus granulatus*, Massy (1926, p. 165).

Type specimen.—Not traced (? Holotype).

Specimens examined.—

A. *West Atlantic.*

(*a*) In Brit. Mus.

One (♀) [C. 157] from Porto Caballo, Venezuela: 49.12.7.60. One (♂) [C. 199] from Bermuda: 72.9.2.5. Two (♀♀) [C. 125–6] from Jamaica ("*eudora*"): 46.8.31.3. One (♀) [C. 96] from "West Indies": 69.5.22.27. One (♀) [C. 259] from Bahia: 1903.9.17.9. One (♀) [C. 258] from E. Brazil: 1908.12.11.1. One (♂) [C. 97] from Rio de Janeiro:

19.12.30.41. One (♂) [C. 98] from same locality: 27.8.2.1. Six (♂♀♀♀♀♀) from Fernando Noronha: 89.4.24.14.

(*b*) In the M.H.N., Paris.

One from Martinique.

B. *N. Eastern Atlantic.*

(*a*) In Brit. Mus.

One (♀) from Plymouth: 27.2.10.2. Two (♀♀) from "South Coast" [England]: 72.2.3.12–13. Four (♀♀♀♂) (loan) from Morocco. One (♀) from "the Mediterranean": 67.3.27.9. One (♀) from the Azores: 55.7.6.73. Two (♀♀) from Porto Santo (young) [C. 152–3]: 1912.12.31.118–19. One (♀) [C. 86] from the same locality: 98.5.10.2. Three (♀♀♂) [C. 100–2] from the Canaries, unregistered. Four (♂♂♀♀) [C. 85, 103, 118–19] from St. Vincent's, Cape Verde: 51.1.24.1, 50.9.29.2, 89.4.24.17 and one unregistered. One (♂) from "W. Africa" [C. 260]: 1928.3.17.1. One (? sex) [C. 115*a*] from 9° S., 34° W.: 89.4.24.15. Two (♂♀) [C. 262, 371] from Sierre Leone: 1928.3.17.2–3. One (♀) from Ascension Island [C. 269] ("*occidentalis*," type): 89.4.24.14. Three (♀♀♀) [C. 93–5] from unknown locality: 65.5.23.1.

(*b*) In M.H.N., Paris.

Two from Nice. One (♀) from Boulogne. One from Corte (?). One from Boulogne. One from Algiers. One from Goree. One from Dakka.

(*c*) In Senck. Inst., Frankfurt a/M.

One from Genoa.

(*d*) In Z.M., Berlin.

One from Ascension Island.

C. *South and East Africa.*

(*a*) In Brit. Mus.

One (♂) [C. 108] from Port Elizabeth: 90.9.4.4. Three (♂♀) from Natal [C. 105–7]: 1924.9.9.11–13. One (♀) [C. 109] from Cape Colony: 1926.10.20.30. One (juv.) from the Cape of Good Hope: 89.4.24.18.

(*b*) In Senck. Inst., Frankfurt a/M.

One from Simonstown. One from Cape Town.

(*c*) In Z.M., Berlin.

One from Haifa.

D. *South-West Atlantic.*

(*a*) In Brit. Mus.

One (♀) ("*Octopus occidentalis*," Massy, 1916B) [C. 68] from S. Trinidad: 1919.12.30.40.

E. *Indian Seas.*

(*a*) In Brit. Mus.

One (♂) [C. 110] from Ramesvaram, Madras: 94.9.6.1. Two (♀♂) [C. 111, 113] from "India": 83.10.27.28–9. One (♀) [C. 217] from Travancore: 1906.9.16.1. Two (♀♀) [C. 328–9] from the Gulf of Martaban: 88.12.4.1–2. One (♀) [C. 115 bis] from Amirante Atoll: 1921.9.14.270.

(*b*) In M.H.N., Paris.

One from Mauritius. One from the Grand Comoro.

(*c*) In Z.M., Berlin.

One from Mergui. One from Makassar.

F. *Malaysia, China and Japan, Pacific.*

(*a*) In Brit. Mus.

One (♀) [C. 111] from Indo China (loan). One (♂) from Amoy: 18.3.31.9. Two (♀♂) from Inland Sea, Japan: 1902.11.19.17–18. One (♀) [C. 120] from "the Pacific," unregistered. One (♀) [C. 116] from Thursday Island, Torres Straits: 82.2.23.568. One (? sex) [C. 168] from Fiji: 89.4.24.24. One (♀) [C. 186] from Cambodia: 1928.1.22.2.

(*b*) In M.H.N., Paris.

One from the Sandwich Islands.

(*c*) In U.M., Jena.

One from Amboina.

G. *Australia.*

(*a*) In Brit. Mus.

One (♀) [C. 112] from Sydney: 90.12.13.46*a*. One (♀) [C. 218] from Southport, Queensland: 1928.3.14.1. One (♀) [C. 117] from the Tweed River, N.S. Wales, unregistered. One (♂) [C. 160] from Port Essington (type of *O. polyzenia*).

Distribution.—On the assumption that the synonymy proposed on p. 63 is correct the distribution of this species is as follows:—

N. Carolina (Verrill, 1880*b*). *Florida* (Calkins, 1878). *Bermuda* (Peile, 1926). *W. Indies* (Orbigny, 1840; Verrill, 1883; Joubin, 1898; Brit. Mus.). ? *Venezuela* (Brit. Mus.). *English Channel* (Orbigny, 1840; Brit. Mus. (?)). *Mediterranean* (Orbigny, 1840; Blainville, 1826; Tozzeti, 1869; Gray, 1849; Fra Piero, 1895; Pallary, 1920). *Morocco and W. Africa* (Lönnberg, 1896; Bosc, 1792; Hoyle, 1886; Joubin, 1893). *S. Atlantic* (Orbigny, 1840; Brit. Mus.). *Brazil* (Gray, 1849; Hoyle, 1886; Jatta, 1889; Massy, 1916B). *Cape of Good Hope* (Hoyle, 1886; Thiele, 1915 and 1921; Robson, 1924; Massy, 1925–6). *Persian Gulf*, etc. (Goodrich, 1896; Massy, 1916A). *Indian Ocean* (Orbigny, 1840; Gray, 1849; Hoyle, 1886 and 1904*b*; Goodrich, 1896; Massy, 1916A; Robson, 1921; Winckworth, 1926). *Red Sea* (Hoyle, 1907*a*; Weindl, 1912; Wülker, 1920). *E. Indian Seas* (Orbigny, 1840; Brock, 1887; Goodrich, 1896; Wülker, 1910). *China* (Brit. Mus.). *Japan* (Joubin, 1897*a*; Ortmann, 1888; Wülker, 1910). *Australia* (Gray, 1849; Smith, 1884; Brazier, 1892; Brit. Mus.). *E. Pacific* (Gray, *l.c.*, Bayern, 1900, Hoyle, 1904*a*, Odhner, 1922).

The records from the outlying parts of this distributional area are ambiguous. That from Valparaiso (Gray, 1849) is certainly to be rejected (*infra*), and that of Hoyle (1904*a*, '*occidentalis*' (?)), from the Galapagos Islands may be doubted. Hoyle gives no description of the specimen obtained; nor does Odhner describe his Juan Fernandez specimen. Orbigny's "Boulogne" record is uncertain; Fischer (1867, p. 12) suggests that the Boulogne specimen was a form of *Octopus vulgaris*. No recent records from the Channel are known. The Plymouth specimen (p. 64) is not a pure *rugosus*, but has *vulgaris* traits. It is absent from Grimpe's North Sea list (1925), and, although the Mediterranean records are fairly numerous, it does not figure in Jatta and Naef's monographs, nor from the lists of Ninni, Stossich and Leidenfrost of the Adriatic fauna. On the American side of the N. Atlantic it is recorded as far north as Bermuda (Peile, 1926, p. 98) and probably from the coast of N. Carolina

(Verrill, 1880*b*, p. 368). Gray's "Valparaiso" specimen is no longer in the collection, so that I cannot check this probably inaccurate statement.

Description.—The body is typically saccular, its width being about 72% of its length. The head is only a little narrower than the body, and the eyes are moderately prominent. The arms are rather short and on an average 77·5% of the total length. The suckers are closely set and alternate. In many individuals they are rendered conspicuous by the contrast of their pale colour against the dark edging of the arms. The largest suckers, which are usually on the second arms at the 6th–9th pair, attain a maximum diameter of 12% of the mantel-length. There is usually very little difference between males and females in this respect, but in some males the largest suckers are sharply distinguished in size from their neighbours. The arms are usually in the order 2.3.4.1, though the third are quite often the longest. The web is bilaterally symmetrical

Fig. 8.—*Octopus rugosus*. Radula.

and has the formula CDBAE (CBDAE and DCBAE being quite common). Sector A is usually deeply incised. The web is commonly under a quarter of the arm-length, viz. about 23%, and there is usually a very high disparity-index. The mantel-aperture is wide (B–C). The funnel is moderately prominent and free for about half its length. The locking ridge is usually, continuous from side to side. The funnel-organ is very variable, being either W-, W-, or W-shaped. There are 8–11 filaments aside in each demibranch. The radula in the specimens examined by me is variable (see Table, p. 70), and it is not easy to summarize its main features. The rhachidian is always symmetrical, though in one specimen (C. 97) there is a noticeable lag on one side which misled me into describing it as asymmetrical (1925, p. 105). Each series consists of 3–5 teeth; but the nature of the seriation is variable (see Table, *l.c.*). The first lateral is wide and its cusp is high or low. The second lateral is less variable. There is always a well-marked heel, but in Atlantic and Indo-Pacific forms alike the latter may or may not bear a cusp. The third laterals are usually rather straight and slender. Reproductive organs—(1) *Male.*

The hectocotylus is figured and described on p. 69. The end-organ is usually about 4% of the arm-length. The terminal part of the penis is usually long and slender. The appendix is small. (2) *Female.* The Indo-Pacific forms have the distal part of the oviduct shorter than the Atlantic examples (Indo-Pacific, average of seven = 29%, Atlantic, average of six = 39%); but this difference requires further investigation. The oviducal gland is small and in one specimen it was double (see p. 18). The sculpture is discussed on p. 68. It consists of close granules, single and small warts or star-shaped groups of small warts, and is usually well developed on the inside of the web. Cirrhi are usually but not invariably present around the eyes and on the dorsal surface of the body. The colour is variable. There is most frequently a network of fine lines of a dark purplish-brown on a paler ground. This is most clearly seen on the head, web and arms. Sometimes the colour is a more homogeneous purple or dark grey. A single black individual has been recorded.

Maximum size.—356 mm. (Bermudas, Brit. Mus.). ? 560 mm. (Bayern).

Habits.—Practically nothing is known concerning the habits of this species. It is emphatically a shallow-water form,* and is found in the littoral zone, on coral reefs and among rocks. There is a specimen in the British Museum preserved along with some Octopod eggs (presumably of the same species) deposited inside a valve of *Modiola*. The oviposition of this and other species is discussed on p. 22 and in a separate work (Robson, 1928*b*, p. 646).

Variation.—The range of variation of eleven characters is given on p. 42. From this it will be seen that, as in *Octopus vulgaris*, the range is very considerable in nearly all the characters. It is necessary therefore to ascertain first to what extent the total population is homogeneous, and then how far it is possible to recognize distinct, though subsidiary, groupings within it.

A. In order to obtain a measure of the homogeneity of the population, *i.e.* the extent to which individuals having the same set of characters are represented in it, I selected seven of the characters which can be measured most satisfactorily in our material, and tabulated the measurements of those characters in thirty individual specimens selected at random. The means for these characters in the total population treated as *rugosus* were ascertained, and arbitrary figures were chosen just above and below the mean, so that any measurement falling within these figures could be treated as "nearly average." The figures so employed were as follows :—

	Width index.	Arm formula.	Arm index.	Web formula.	Web index.	Character of skin.	Pattern.
Mean of whole sample .	72	2341	78	CDBAE	24	Granular.	Reticulate.
"Nearly average" . .	68–76	3241 . 2341	76–80	CDBAE DCBAE BDCAE BCDAE	20–28		

* There is a single record from deep water, viz. 457–589 fathoms (Massy, 1916A, p. 189).

The constitution of the thirty individuals measured in respect of these seven characters thus assessed was as follows :—

1	had	$\frac{7}{7}$	" nearly average "	characters.
4	,,	$\frac{6}{7}$	,, ,,	,,
9	,,	$\frac{5}{7}$	,, ,,	,,
8	,,	$\frac{4}{7}$	,, ,,	,,
5	,,	$\frac{3}{7}$	,, ,,	,,
3	,,	$\frac{2}{7}$	,, ,,	,,

In other words, twenty-two out of thirty specimens were " nearly average " in respect of more than half the seven characters. Pure *rugosus* individuals are very uncommon, the usual type encountered exhibits a certain number of extreme characters, and there are always a number (in this case eight out of thirty) which are only provisionally included in *rugosus*. In short, "*rugosus*," while fairly constant, varies rather markedly in certain characters.

The most obvious distinction to seek within this group is one between Atlantic and Indo-Pacific forms. I accordingly divided my specimens into two sets, one composed of Atlantic and one of Indo-Pacific forms. The result, which is given on p. 42, is unmistakable as far as the available material goes. The two sets of measurements for these groups are in very close agreement, and though there are admittedly certain differences, they are, when we consider the number of specimens, insignificant. It is true that there is a distinct difference between the hectocotylus of the majority of Atlantic and that of the Indo-Pacific forms. But as (1) these differences are not correlated with others and (2) the " Pacific " type occasionally turns up in Atlantic specimens, I am unwilling to establish taxonomic distinctions on them. Lastly, I am unable by taking various groups of characters represented by extreme individuals to find any regularly occurring or frequently represented subdivisions of *rugosus*. Two extreme types represented by single individuals seem to merit varietal status, but we require more information as to their frequency in nature. It remains to discuss three characters the variation of which is of special interest.

(1) *The Sculpture.* In all probability the state of preservation of the skin has a very considerable influence on the type of sculpture. Age also may be an important factor in determining the latter. At present, however, the effect of age and preservation are not known and have to be disregarded. With this qualification we may recognize three main types of sculpture in this species. 1. *Granules*, usually pointed. 2. *Warts*, most often rounded and boss-like. 3. "*Stars*" which may be (*a*) diffuse, a central wart surrounded by distinct and separate smaller warts, (*b*) compact (more or less like the *pallida*-pattern, Hoyle (1886, Pl. 1, fig. 2)). But all these types grade into one another, and in the same individual it is possible to find types 1, 2 and 3*a*. 3*b* is rare and will be discussed anon. There is no regular correlation of any one type of sculpture with any other structural feature. Ocular and dorsal cirrhi may or may not be present, but they are very irregular in occurrence and I do not attach much importance to them. Class 3*b* is very interesting It is seen in two cases (C. 110 very clearly; C. 112 less obviously), and is also recorded by

Massy (1925, p. 223) for South African specimens and *O. vulgaris* (?) from Plymouth, and possibly by Winckworth (1926, p. 324). Seen in contrast with the other types the warts appear as close, sharply-defined four- and five-rayed prominences usually with a central knob. They are linked up with the diffuse " stars " by intermediate forms. The type recalls instantly that seen in *Octopus pallida* ("*boscii*," Auctt.), and for a time I was under the impression that either *O. pallida* was a form of *rugosus* or else that the examples with this sculpture which I was treating as *rugosus* were wrongly determined. I am now convinced that *pallida* is a distinct species and that specimens C. 110 and 112 are rightly

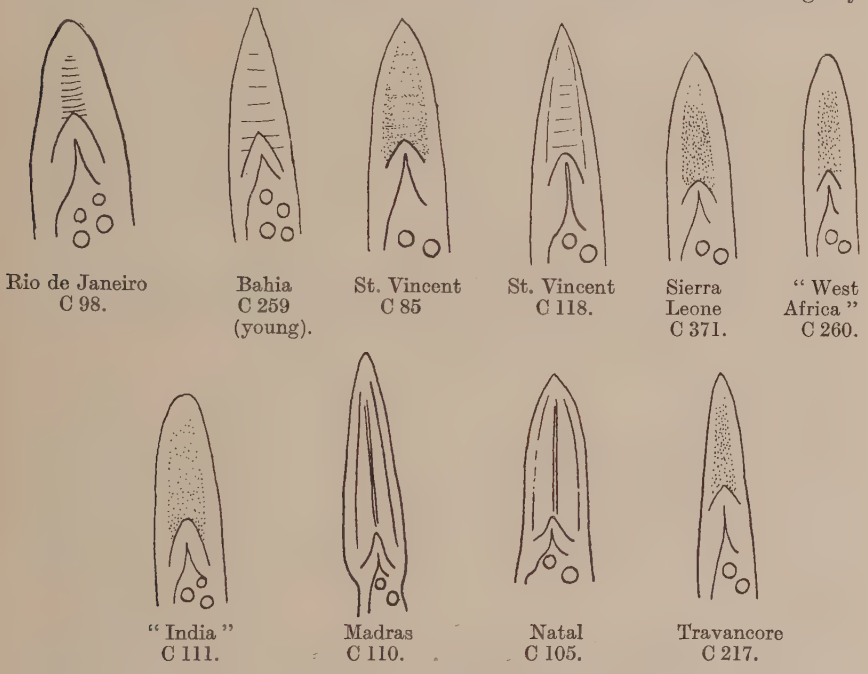

Rio de Janeiro C 98.
Bahia C 259 (young).
St. Vincent C 85
St. Vincent C 118.
Sierra Leone C 371.
" West Africa " C 260.
" India " C 111.
Madras C 110.
Natal C 105.
Travancore C 217.

Fig. 9.—*Octopus rugosus*. Hectocotylus of various examples.

determined. But as far as the sculpture is concerned these specimens have a distinct leaning towards *pallida* and may be hybrids.

The sculpture cannot be used to distinguish the Indo-Pacific and Atlantic forms. Not only do the same types occur in each area, but the resemblance between particular individuals is extraordinarily close, *e.g.* between C. 97 (Rio de Janeiro, " Terra Nova ") and C. 107 (Natal), and between C. 90 (Mauritania) and C. 304 (Japan). I think it is likely that the sculpture of the Indo-Pacific forms may be eventually shown to be coarser and more abundant in the " star " type.

(2) *The Hectocotylus*. The form of the terminal organ is very diverse, as will be seen from Fig. 9. Indeed were it not for the large measure of agreement in other characters one would at first sight consider that several different species were represented. On closer examination, however, the various organs will be seen to be referable to two main types : one in which the calamus is close to the last sucker and one in which it is

placed nearly half-way up the ligula. The first is found most often among Oriental forms, the second among Atlantic types. My series of well-preserved hectocotyli is, however, very small, and I do not know how constant the above-mentioned difference is. It will be seen that the long calamus may occur in Oriental forms (No. 217), and there is some intermediacy (No. 7).

(3) *The Radula.* The marked variation in the radula is best exhibited in the annexed table. A very singular form of variation is seen in the two specimens referred to as "*O. occidentalis*," and in one from Fernando Noronha, in which a change of rhythm occurs (cf. Robson, 1925, p. 104).

(4) A few miscellaneous observations must be recorded :—

i. I have seen two examples (M.H.N., Paris) in which the very common reticulate pattern is absent entirely and the colour is uniform dark purple.

ii. A specimen in the Senckenberg Museum, Frankfort, has extremely long arms (89%) and a web with formula ABCDE. The sections of the web are, however, subequal and the animal is otherwise like *rugosus*. It may be a hybrid between that species and *macropus*.

iii. There are in the Berlin Museum four examples from the Gulf of Mexico which exhibit extremely interesting intermediate stages between *rugosus* and *vulgaris*.

TABLE A.

Variation in the Radula of *Octopus rugosus*.

(The rhachidian tooth is not represented by the usual symbols, but by a formula indicating the number of cusps a side on each tooth in the typical series. Thus 211 indicates that in each series of three teeth there are two cusps a side on the first tooth and one cusp a side on each of the next two teeth).

Specimen.	Rhachidian.	Lateral 1.	Lateral 2.	Lateral 3.
W. Indies	211 2111 111	Base long; cusp moderate	Entocone absent	Nearly straight
Porto Santo	2211 or 111 Irregular	Base long; cusp high	Entocone present	Nearly straight
Cape Verde	21 211	Base long; cusp moderate	Entocone present	Nearly straight (thick)
Rio de Janeiro	2211 Irregular, some teeth asymmetrical	Base long; cusp high	Entocone present	Nearly straight (thin)
Rio de Janeiro	211 2111	Base long; cusp low	Entocone absent	Nearly straight
Port Elizabeth	2221	Base long; cusp low	Entocone present	Nearly straight
Natal	21	Base long; cusp high	Entocone absent	Nearly straight
Madras	1111	Base long; cusp high	Entocone absent	Nearly straight
Xmas Id.	21	Base short; cusp high	Entocone present	Nearly straight
Sydney	2211	Base long; cusp high	Entocone present	Moderately curved

Remarks.—The identity and composition of this species is one of the most difficult systematic problems in the study of the Cephalopoda. A variety of names has been given to the forms here included in the one species, and unfortunately names like *granulatus*, *tuberculatus* and *rugosus* have been freely used during the past hundred years without any attempt to define with exactness the forms indicated. Although I am confident that the majority of forms described under one or another of these names should be regarded as conspecific, it is not at all certain whether *all* the forms thus described are really referable to the same species. Consequently the limits of the species are difficult to appreciate and its exact distribution is uncertain. The problem is complicated by the fact that certain nomenclatorial difficulties are involved. The two problems, viz. (1) the composition of the species and (2) the name to be given to it, are treated as far as possible under different heads.

For over a century systematists have recognized a small Octopod with a granular skin, arms about three times as long as the mantle, a web deeply incised between the dorsal arms and a small hectocotylus. It has been recorded at various points from the Mediterranean eastwards to Japan and Australia. The specimens have often been given different specific names, and the dimensions of the various parts and the surface-sculpture are rather differently given.

In 1792 Bosc (*l.c.*) gave the name *Sepia rugosa* to a Senegalese form with granular skin. From his figure and description it is not easy to ascertain to what he was referring; but its granular skin, the fact that the web is granular inside and out, the width index of the mantle (1 : 1½) and the size of the arms all point to the widely distributed form just mentioned. The web according to the figure is very shallow, about one-third the length of the mantle, whereas in the "*rugosus*" of modern writers it is always over one-half that length. I am inclined to disregard the proportions indicated in a drawing of this date. It is difficult to see what Bosc had before him, if it was not the form that goes by his specific name to-day. It is just possible that it might be an aberrant form of *vulgaris*; but this is not very likely. Bosc's type is unknown; but I think it is reasonable to conclude that he had before him an example of the small, rough-skinned Atlantic form, and that his name is rightly to be applied to the latter. Lamarck (1798, p. 130), following Bosc, gave the name *O. granulatus* to a form which, according to him (1799, p. 20), "a de si grands rapports avec [*O. vulgaris*] que peut-être n'en est-il qu'une variété." He continues: "les deux individus de ce poulpe que j'ai observés dans la collection du Muséum, sont plus grands que le *Sepia rugosa* du Citoyen Bosc. Ils paroissent, malgré cela, appartenir à la même espèce, car leur conformation est à peu près la même que celle de ce *Sepia rugosa*; et ce *Sepia rugosa* du Citoyen Bosc au lieu d'être réellement ridé, comme l'exprime son nom spécifique, a seulement, comme mon poulpe granuleux, le corps chagriné ou parsemé de grains ou tubercules." On this evidence and with the admission that Lamarck's type is also unknown we should grant that "*O. granulatus*" is a synonym of *rugosus*.

Blainville (1826) described an *Octopus tuberculatus* from Sicily. The length of its arms relative to the mantle and the order of the arms render it highly probable that this species is to be identified with *O. rugosus*. The characters cited give us no decisive clue to its status. I think we

should be right in provisionally treating this species as synonymous with *rugosus*.*

Orbigny treated the three species so far described in a comprehensive revision (1840). He reduced Lamarck's *granulatus* to a synonym of Bosc's *rugosus* and maintained *tuberculatus* as a distinct form. The chief differences which he recognized between the latter and *rugosus* are as follows :—

O. rugosus.	Senegal.	Granulations of skin regular.
	W. Indies.	No cirrhi.
	Mauritius.	Colour-pattern reticulate.
	Batavia.	
O. tuberculatus.	Mediterranean.	Granulations irregular and multifid.
	English Channel.	Numerous cirrhi.
	West Indies.	No reticulate pattern.
	S. Atlantic.	

Hoyle (1886, 1889) took the same view, but preferred *granulatus* as the name for the Atlanto-Pacific form (*O. rugosus* treated as a synonym) and *tuberculatus* for the Atlantic form.

In 1891 Ortmann, dealing with the Indian Ocean forms, suggested that *rugosus* was the correct name for the Indian form and *granulatus* a synonym thereof. This view was adopted by Massy (1916*a*). Neither author ventured an opinion as to the Atlantic form; but Massy gave "W. Africa" as part of the range of her "*rugosus*" and later (1916, *l.c.*) applied that name to a specimen from Rio de Janeiro. In 1925–6 she gave the name *granulatus* to South African forms with distribution "Azores, Pacific" (etc.). In 1924 I upheld the distinction between Atlantic and Indo-Pacific species; though I pointed out the large amount of transgressive variation between them. In 1926 I endeavoured to maintain this opinion, though with less confidence.

Since that time I have had an opportunity of examining the material described on pp. 63–65, eighty-seven specimens in all, and I am forced to conclude that this array, including forms from the Atlantic, Indian Ocean, Malayan and Australasian waters is really a homogeneous assemblage and can only be treated as a single species. Although there are marked divergences in the form of the ligula and also in the second lateral tooth of the radula, the geographical distribution of the specimens that illustrate these divergences does not suggest that there are two species involved, one inhabiting the Atlantic, the other the Indo-Pacific region, or support Orbigny's recognition of an Atlantic species and another found in both the Atlantic and the Indo-Pacific region.

As for the name to be applied to this species, the type of Bosc's *rugosus* is no longer accessible; but I think it is a reasonable inference that he had before him a specimen of this species. I consider that Lamarck's *granulatus* and Blainville's *tuberculatus*, the types of neither of which are available, are also referable to it and should be treated as synonyms of *rugosus*. The other species which I propose to relegate to the synonymy of the latter are discussed individually.

The specific name *mas* given in his synonymy (1841, p. 18) by Orbigny is not, of course, acceptable. It was used in the non-Linnean "Thesaurus" of Seba ("explication des planches") obviously not as a specific name but

* The "*Octopus tuberculatus*" of Risso (p. 63) is probably an *Ocythoë*; that of Delle Chiaje (1830, p. 56, pl. LV) is certainly referable to that genus.

with "*Polypus Foemina*" (f. 4), as distinguishing the male from the female specimens. It is not used by Bruguière (1789) nor by Baker (1758), as stated by Orbigny. "*Sepia granulosa*" (Bosc, 1802) cited in the same synonymy also seems to be an error. In the work quoted (p. 47) there is only "Sèche granuleuse, *Sepia granulata*."

1. "Le poulpe Américain," de Montfort, 1802; *Octopus Backerii*, Orbigny, 1826 (*Barkerii, id.* (1840, p. 46)); *O. americanus*, Blainville, 1826; *O. vulgaris*, var. *americanus*, Orbigny, 1841.

In 1758 Baker (Barker auctt.!) described and figured a West Indian form of *Octopus* without specific designation. From its "skin granulated like shagreen," its short and backwardly coiled arms, it would seem likely that this is our *rugosus*. Seba's "*Polypus americanus*, pelagius" and Montfort's "poulpe Américain" are probably the same form. In 1841 Orbigny treated this form as a synonym of *rugosus*. In his plates, however, he figures "*Octopus vulgaris, var. americanus*," and I do not think there can be much doubt that a form of *vulgaris* is depicted there. The question of the identity of some of the American forms of *vulgaris* is, however, a little obscure (cf. p. 62). Blainville's *americanus* is, as far as I can judge from the description, a form of *rugosus*.

2. *Octopus geryonea*, Gray, 1849.

I have no doubt as to the identity of this form with *rugosus*. The type is a single, worn specimen from Bahia, probably an old animal. The proportions and general facies are very *rugosus*-like. The skin alone constitutes a point of difference, as it is wrinkled, not granular or warty, and vaguely resembles that of *O. vulgaris*.

3. *Octopus polyzenia*, Gray, 1849.

The type of this is a young specimen (not in very good condition), which from its proportions, sculpture, etc., seems to have strong affinities with *rugosus*.

4. *Octopus eudora*, Gray, 1849.

The two type specimens do not differ in any important respect from *rugosus*. The specimens are not smooth, as stated by Gray. Distinct traces of fine granulation are to be seen in both and of warts on the inside of the larger specimen's web. The characteristic dark reticulation is seen in both.

5. *Octopus favonia*, Gray, 1849.

I cannot find any satisfactory grounds for regarding this as a distinct species.

6. ? *Octopus globosus*, Appellöf, 1886.

Ortmann (*l.c.*, p. 669) treats this species as a synonym of *rugosus*. Massy (1916A, p. 202) has amplified the original description with some data obtained from three very young specimens, and Goodrich (1896, p. 82) has figured the hectocotylus. On the whole I am inclined to think that Ortmann is correct, though it would be necessary to see the type before making a final decision (see p. 93).

(Type in the Zoological Museum, Uppsala University.)

7. *Octopus occidentalis*, Hoyle, 1886.

I can find no differences in the external parts between the type

specimen of Hoyle's species (Ascension Id.) and specimens of *rugosus* from the Atlantic. Similarly, Massy's specimen from South Trinidad cannot be distinguished from *rugosus*. The radulae of these two specimens both exhibit a very peculiar feature (a change of seriation), which I have not met in other specimens of *rugosus* (Robson, 1925, p. 104). Although this feature is very peculiar and has been found in specimens from localities very remote from each other, I do not feel that it affords sufficient ground for maintaining Hoyle's species in view of the close resemblance to *rugosus* on other grounds. The radula of *rugosus* is very variable, and it is not a feature to which we can at present attach much taxonomic value. The change of rhythm alluded to occurs in another undoubted *rugosus* from Fernando Noronha, and a more or less similar phenomenon in some examples from St. Thomas, W.I.

Octopus (Octopus) rugosus, var. **sanctae helenae,** n. var.

Octopus sanctae helenae, Auct? MS, Brit. Mus.

Holotype.—In Brit. Mus.

Specimen seen.—One specimen (♀) from St. Helena : 68.3.12.1.

Distribution.—Only known from the type locality.

Description.—This specimen is very much distorted, and has been dissected. It is, therefore, difficult to speak with certainty about all its characteristics. Nevertheless, it is so distinctive in certain respects that I can hardly avoid giving it a varietal status.

The skin is covered with low (rather worn), very clearly cut multifid warts. A few of these, especially on the sides, are 5-stellate, but on the dorsum they show a very marked tendency to form longitudinal ridges. On the web and arms they become smaller and rougher (though more obscure), and the arms are shagreened by them. The web is very deep, 33%, the maximum attained by Atlantic *rugosus* and its disparity index is very high (44%). The gill filaments number eleven aside, and are more numerous than is usually found in *rugosus*. The mantle and head, though distorted, seem to have been very much narrower than is usual in *rugosus*. I estimate the width index to have been about 50%, which is much below the minimum of *rugosus*.

Such other characters as can be ascertained are well within the range of *O. rugosus*.

The name *sanctae helenae*, evidently a MS. one, was written on the label of the bottle containing this specimen. It cannot be found in any published work.

Octopus (Octopus) verrucosus, Hoyle.

(Text-fig. 10.)

Octopus verrucosus, Hoyle (1885, p. 122), *id.* (1886, p. 79, Pl. 4); *Polypus verrucosus*, Massy (1925, p. 205); *? Octopus octopodia*, var. *verrucosa*, Dautzenberg (1912, p. 2); *Octopus verrucosus*, Robson (1925, p. 105).

Type (*? Holotype*).—In Brit. Mus. (C. 121).

Specimen seen.—In Brit. Mus.

One specimen (♂) from Inaccessible Id., Tristan d'Acunha : 89.4.24.16.

Distribution.—Only known from the type locality, Tristan d'Acunha; (a preparation in the Zoological Dept., Brit. Mus., labelled by the late

Dr. H. M. Gwatkin as "*verrucosus*" from Funafuti, is probably erroneously identified). Dautzenberg's "var. *verrucosa*" is undescribed.

Description.—The body is accidentally distorted, but seems to have been saccular or broadly pear-shaped. The head is much narrower than the body. There are distinct pre- and post-ocular constrictions. The arms are in the order 2.3.4.1 and are 80% of the body-length. The suckers are abruptly enlarged, and the largest attain the great diameter of 26% of the mantle-length. The web has the formula C.D.B.E.A. and is rather shallow (18%). The funnel is free for one-third of its length; the funnel-organ is W-shaped. The hectocotylus has a very minute extremity, actually under 1% of the length of the arm. The edges of the ligula are thick and well-defined, and it has three very well-defined laminae copulatoriae and a blunt extremity. The calamus reaches about half-way along the ligula. The penis is short and stout. The sculpture consists of irregular closely set warts which tend to be slightly multifid on their apices. Some of them approach the *pallida* pattern. There are a few larger than the rest down each side. The colour (in spirit) is a dull purplish-grey above, much lighter below. On the web and arms there is a distinct trace of dark reticulation.

Maximum size.—470 mm. (Hoyle).

Fig. 10.—*Octopus verrucosus.* Hectocotylus. × 13.

Remarks.—This is a very interesting form. It seems to exhibit characters of *O. vulgaris* and *O. rugosus* in combination with individual peculiarities. In nearly all its measurable characters it comes within the range of variation of *rugosus*, and the arms and web-formula are like those of *rugosus*. It also exhibits the purple reticulation seen in that species. The arms are rather long (83%) and the head very narrow, more as in *O. vulgaris*. The sculpture is composed of dense, closely approximated, irregular warts, such as are never seen in *rugosus*. There is a faint suggestion of the *pallida* pattern about them, but they are never clearly defined and 5-stellate as in that form. The sculpture indeed is more like that of *vulgaris*, but is neater and finer. Peculiar features are: (*a*) The suckers of the second arm attain a size of 26% of the mantle-length. (*b*) The penis is very short and stout, not slender and elongate as in *rugosus* and *vulgaris*. (*c*) The hectocotylus, in addition to being very small, is of rather a different type from any seen in *rugosus* and *vulgaris*. The sides of the ligula are thicker and its laminae copulatoriae are better marked than in any specimen of *rugosus* I have seen.

The general impression is of a combination of characters mainly found in *rugosus* and *vulgaris*, but including some rather extreme *rugosus* features and three quite distinctive characters. It is obviously an offshoot from the main *rugosus* type, but sufficiently distinct to be given a separate position.

Octopus (Octopus) carolinensis, Verrill.

Octopus Carolinensis, Verrill (1884*a*, p. 235), *id.* (1884*b*, Pl. XLII, fig. 4).
Holotype.—In U.S. Nat. Mus.

Distribution.—Cape Hatteras (North Carolina) (type locality), in 142 fathoms.

Definition.—The body is broadly oblong and nearly as wide as it is long. The head is as wide as the body and the eyes are moderately prominent. The arms are in the order 2.3.4.1. They are more or less subequal, and the longest are 76% of the total length. The web is deeply incised between the dorsal arms and is probably widest in sections C and D, where it is over 25% of the arm-length. From the figure it seems to have the formula C.D.B.A.E. or C.B.D.A.E. The web is prolonged as a wide membrane up the arms. The suckers attain a maximum diameter of 9%. The surface is covered with "minute but prominent verrucae." There are no pallial cirrhi; but the eyes are surrounded by small warts. The colour (in alcohol) is rather dark purplish-brown above, yellowish-white, rather thickly speckled with orange-brown chromatophores on the under surface.
Maximum length.—94 mm. (body and second arms) (Verrill).

Remarks.—This species has only once been recorded. I am a little suspicious that it may be a form of *O. rugosus*. Verrill (1880*b*, p. 368) states that a form very like that species has been found at Beaufort, North Carolina. The diagnosis of *O. carolinensis* given by Verrill, with one exception, does not tell us anything that is not equally applicable to *rugosus*. (1) The short, squat body, (2) the ventral colouring, and (3) the web, which is very deep and quite outside the range of *rugosus*, are its most individual features. The type is a rather small and possibly immature specimen. It was obtained from fairly deep water (142 fathoms) and may conceivably be a representative of some better-known deep-water species.

Octopus (Octopus) pentherinus, Rochebrune & Mabille.

Octopus pentherinus, Rochebrune & Mabille (1889, p. H7).
Type.—? In M.H.N., Paris, (? holotype).
Specimen seen.—One ♀ from Punta Areñas (Mission du Cap Horn, 1883) (Drag. 204), in M.H.N., Paris.

Distribution.—Orange Bay, Patagonia (type locality); Punta Areñas.

Description.—I have thought it better to give first the original description and then an account of the Punta Areñas specimen.

"Corps longuement ovoïde, lisse; tête large, quadrangulaire, yeux de petite dimension; bras larges, subarrondis, filiformes à leur pointe et légèrement contournés, portant des cupules larges à la base et diminuant de volume jusqu'à la pointe où elles ont de très faibles dimensions; la membrane de l'ombrelle est peu développée. Animal d'un violet foncé, orné de larges taches irrégulières d'un jaune orange pâle. Long. corp. 0,018 : lat. corp. 0,009 : long, med. brach 0,019." (R. & M.).

The Punta Areñas specimen.

This is in very bad condition, and it is not easy to make out the general shape. The head is wide, 70% of the total length. The arms are in the

order 3.1.2.4, and the longest arms are at least 83% of the total length. The suckers attain a maximum diameter of 13%. The web has the formula B = C = D.A.E. All the sections except E are subequal. The web is about 22% of the arms in length. The funnel is very short and is almost entirely buried in the tissues of the head. The funnel-organ is imperfectly preserved. The viscera have been removed from the body. The skin is smooth but wrinkled and is a dark purple maculated with still darker colour.

Remarks.—The authors cite (giving date alone, [1887]) an earlier description published by themselves which I cannot trace.

The type-description is very superficial and it is not possible to obtain a clear idea of the species from it. The type could not be found in the Paris Museum. There is a specimen (see above) obtained by the same expedition from another locality and apparently labelled by de Rochebrune. This, however, does not agree at all with the original description and is either wrongly labelled or else the authors of *O. pentherinus* were at fault in measuring the type. The disparity in the arm-lengths and the colour is very noticeable. In the absence of the type and with such an imperfect description it is impossible to do more than record this as a hypothetical species. It should possibly be placed in *Joubinia*; but its internal anatomy is unknown.

Octopus (Octopus) tonganus, Hoyle.

(Text-figs. 11, 12.)

Octopus tonganus, Hoyle (1885, p. 225), *id.* (1886, p. 83, Pl. VIII, figs. 1–2), Hedley (1899, pp. 520, 550); ? *Polypus tonganus*, Hoyle (1904*a*, p. 17), *id.* (1905, p. 978), Wülker (1913, p. 456), Massy (1916A, p. 200).

Syntypes.—In Brit. Mus.

Specimens seen.

(*a*) In Brit. Mus.

Two (♂♀) from Tongatabu: 1889.4.24.22–23 (Types). One (♀) Tongatabu: 90.12.28.83.

(*b*) In Senck. Inst., Frankfurt a/M.

Two (♀♀) from Dobo and Ngaibor, Aru Islands (R. Merton, 1908), (? status).

Distribution.—Friendly Islands (Hoyle: British Museum); Funafuti, Ellice Isles (Hedley); Malé Atoll, Maldive Isles (Hoyle); ? Aru Islands (Wülker); Arabian Sea (Massy); " Pacific Ocean, between Columbia and Mexico " (" no more precise locality ") (Hoyle) [?]; on reefs and shore and in lagoons and shallow water down to 58 fathoms.

Description.—The mantle is saccular and wide and the head is also wide. The arms are long and in one specimen attain a maximum length of 88%. The suckers in the male are enlarged on the lateral arms and attain a maximum size of 21% of the mantle-length. In Massy's male specimen they are evidently affected by regeneration. In the female they do not exceed 12%. The web is moderate in depth (11–18%), and the disparity is rather marked. A is usually the shallowest, though in Massy's specimen E is the shallowest. The funnel is rather prominent

and is free for three-fifths of its length. The funnel-organ is apparently W-shaped; but in no case is it well preserved. The surface may be nearly smooth or the sparse dorsal tubercles may form longitudinal ridges (Hoyle, 1905). The coloration is buff or greyish, darker in Hoyle's Malé specimen. There are 7–12 gill filaments. The *radula*. The rhachidian has an A_2 seriation. The first lateral is of a very uncommon type with a narrow base and high cusp. The third laterals are little curved and very heavy. The penis is of the *vulgaris* type, though the appendix is less developed than in that species. The hectocotylus is very minute, but in the type specimen it has a well-formed calamus and the ligula is neatly excavated. The anterior part of the oviduct is 45–39% of the mantle-length.

Habits.—This is evidently a littoral form. The majority of the records are from reefs or shore pools and lagoons. Massy gives a record of 56–58 fathoms for her Arabian Sea specimen.

Maximum size.—285 mm. (Hoyle).

Variation.—This is rather an indeterminate form and requires more

Fig. 11.—*Octopus tonganus.* Radula.

Fig. 12.—*Octopus tonganus.* Hectocotylus (after Hoyle).

study. It is fruitless to discuss its variation very fully, as the exact identity of the various specimens assigned to it is in doubt. Assuming that the records are correct we may notice that Hoyle's Malé Atoll (1905) specimen is darker than the others and has better-developed sculpture, the papillae taking the form of linear ridges. One of the type-specimens has very long arms, viz. 88%, as against 81% in Hoyle's Laccadive specimen.

Remarks.—It is a little difficult to be certain that this species deserve separate recognition. It has affinities with *rugosus*, and may turn out to be a variety of that form. It is distinguished by the very short ligula, longer arms and shallower web, by the excessively large suckers of the male, and by the fact that sector A of the web, though low, is not markedly shallow. The sculpture is very little known, as the available specimens are worn. The characters of the arms and web are not distinctive and are within the range of *rugosus*. Wülker (*l.c.*) thinks it may be a local form of *vulgaris*. Here again the affinity is close; but *tonganus* has (1) a wider and plumper visceral sac, (2) rather longer arms, (3) a smaller hectocotylus, and (4) the form of its first lateral and rhachidian teeth is not found in *vulgaris*.

Octopus (Octopus) bimaculatus, Verrill.

(Text-fig. 13.)

Octopus bimaculatus, Verrill (1883, p. 121, Pl. V, figs. 1 and 6), Brock (1887, pp. 610–11); *Polypus bimaculatus*, Hoyle (1904*a*, p. 16), Berry (1911*a*, p. 301), *id.* (1912*a*, p. 278, Pls. XXXIV, XXXV, fig. 2; Pl. XXXIX, fig. 5), *id.* (1912*c*, p. 87, fig. 48, anatomy).

Specimen seen.—One (♀) from Lower California : 1929.1.14.1.

Syntypes.—In U.S. Nat. Mus.

Distribution.—California (Laguna, San Pedro, San Diego, La Jolla, etc.) (Verrill, Berry); San Salvador (Verrill); Panama (Verrill). There are very few particulars available as to the vertical range. Berry (1912*c*, p. 87) says it is " the common shore Octopod in S. California " and gives (1911) one record of 59–135 fathoms.

Description.—The mantle is elongate, broadly pyriform with the maximum diameter posterior. The head in the adult is slightly narrower than the mantle and separated from the latter by a moderate " neck," the eyes being moderately large (" large," Verrill). The arms are more usually in the order 3.2.4.1., and attain an average length of 80–81 (88 is found in one of Verrill's specimens and 71 in one of Berry's). A single sucker at the edge of the web is very much enlarged. The web is figured by Verrill and the formula seems to be CBDAE, C being nearly twice as deep as E. Verrill gives its maximum depth as 100 mm. (longest arm 550 mm., index 18%); Berry gives a measurement of 74 mm. between the ventral arms alone (index 18%). The hectocotylus is minute. Berry gives measurements of the hectocotylus, but does not say if the third arm measured is that of the right side. If it is, the hectocotylus is about 1·4–1·7% of that arm.

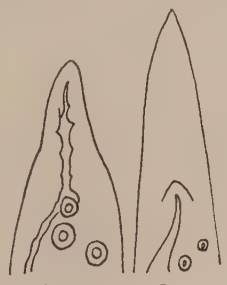


Fig. 13.—*Octopus bimaculatus.* Hectocotylus. (*a*) After Berry, 1912. × c. 10. (*b*) After Verrill. × 6·5.

The ligula is small, pointed and has a moderately deep groove, the calamus being exceedingly minute.* The surface is covered with " prominent, unequal, raised warts," which are more or less obsolete ventrally, the larger (? " cirrhi," (Berry)) being longer in the young form. The colour (preserved specimens) is a dark brownish or purplish grey, sometimes clouded with darker patches. There is a large ocellus between the second and third arm and just in front of the eye. This is usually simple (*i.e.* homogeneous in colour), but in Berry's papers it is described as including a bluish inner ring as in *areolatus* and *ocellatus*. The funnel is free " for much of its length." There are eight filaments a side in each demibranch (Berry, 1912*c*), a rather low number. In the diagram of the alimentary canal given by Berry (*l.c.*) the crop seems to be unusually large and the spiral caecum to be exceptionally well-developed. There is, moreover, a markedly expanded colon. In the male reproductive organs the penis seems to have a very small distal part and a large diverticulum. Needham's organ is very bulky. The distal part of the

* In Berry's figure (1912*a*, Pl. XXXV, fig. 2) the calamus is absent.

oviduct is about 3·5 times as long as the proximal part. The oviducal gland is double.

Habits.—This species according to Berry (1911*a*, p. 302) replaces *O. apollyon* in S. California, where it is very abundant. It is apparently a littoral form found down to 135 fathoms (Berry, *l.c.*).

Variation.—(1) The characteristic ocellus is subject to some marked variation. (A) In Verrill's specimens and in Berry's Laguna example it is a simple homogeneous dark spot. (B) In most of Berry's specimens it is described as composed of (*a*) a dark centre surrounded by (*b*) a narrow, dull-bluish rim, (*c*) outside the latter a wider ring of the same colour as the centre. Some other less important variant types are mentioned by Berry (1912*a*, p. 279).

(2) There is some marked deviation between Verrill's two examples and the four adults of which the measurements are given by Berry.* The former are very wide (index 107 and 85), the latter much narrower (77–65). The difference in head-width between males and females in Berry's table is noticeable, the two males having an index of 55–51, the two females having one of 42–40.

(3) The sculpture varies from numerous "warty papillae" to a nearly smooth condition.

(4) Verrill notes that the ligula of his (large) forms has neither laminae nor a central groove ("spoon-shaped cavity"). Berry, on the contrary, found both and suggests that these structures may be effaced in older specimens.

Remarks.—This common S. Californian Octopus has been very fully described by Verrill and Berry. The radula and funnel-organ are, however, unknown. The species according to Berry replaces *O. apollyon* in S. California. It has been confused with *O. apollyon* in literature; but is amply distinguished from that species by the presence of an ocellus and by the diminutive size of the ligula. As Hoyle states, it seems to be allied to *O. marmoratus* (= *O. cyanea*).

Octopus (Octopus) tenebricus, Smith.

(Text-fig. 14.)

Octopus tenebricus, E. A. Smith (1884, p. 35, Pl. IV, figs. B–B3), Brazier (1892, p. 5).

Syntypes.—In Brit. Mus.

Specimen seen.—Two (♂♀) specimens from Port Denison, Queensland : 81.11.10.13–14 (Types).

Distribution.—Only known from the type locality, Port Denison, Queensland, in 3–4 fathoms.

Description.—The body is of an elongate ovoid shape and distinctly narrow. The head is not wider than the body, as is shown in Smith's figure, but a little narrower. The eyes are, however, very prominent owing to the marked ocular constrictions. The drawing in Smith's paper does not do sufficient justice to the extraordinary eyes, which are conical and very elongate. The head and body are like those of var. *dama*

* In the text and table (p. 42) the "apex-eye" measurement is "calculated."

of *O. defilippi*. The arms are in the order ? 2 = 3 = 4.1. and are long, 84%. The suckers are small (8%), in the larger specimen and about the same size in the smaller (♂). The web has the form DCBAE, A being twice as deep as E. It is shallow on the whole, viz. about 15%. It is extended up the arms as a narrow but very prominent dorsal keel. The funnel is long, tubular and free for about half its length. The funnel-organ is W-shaped. The ligula is 3·7% of the third arm in length. It is narrow, pointed, and exhibits a moderate non-striated excavation. The prominence of the calamus, which is small and basal in position, is rather exaggerated in Smith's drawing. There is a small number of branched papillae on the arm, web, head and body, some of which are plainly retractile and possibly like those of *O. arborescens* (*q.v.*). The body is also marked with low confluent longitudinal ridges of a malleolated type. The colour is uniform dark purplish chocolate.

Size.—(♀) 83 mm.

Variation.—The smaller male is more slender than the female. The longitudinal ridges are less obvious and seem to be broken up into a more granular sculpture.

FIG. 14.—*Octopus tenebricus*. Hectocotylus. × 12.

Remarks.—The coloration and sculpture of this form are characteristic. Smith compares it rightly with *aculeatus*, Orbigny. It also might be a form of *horridus* completely homogeneous in colour. But the extraordinarily prominent and conical eyes, character of sculpture and the ligula separate this form from the long-armed, dark and rough-skinned species. It should be remembered that a melanic phase of *horridus* is known (p. 92).

Octopus (Octopus) mimus, Gould.

Octopus mimus, Gould (1852, p. 473, Pl. 46, 587*a–e*).

Type specimen.—? In U.S.N.Mus., Washington. (? Holotype.)

Distribution.—Callao; only known from the type locality.

Description.—The mantle is ovoid and saccular and the head very narrow (32%), the general appearance reminding one very forcibly of *O. macropus*. The arms are very long (85%). As they are given in the order 3.2.4.1. (in the figure 2 is longer than 3), I do not think that any variation due to accident is likely to conceal the fact, had they been *macropus*-like (1.2.3.4.). The suckers are tolerably large. The web again is not like that of *macropus*, as it is of the form C.D.B.A.E., E being very small. The depth is about 27% of the arms.* The mantle is widely open (C.) and the funnel is long and tapered, its aperture being remarkably small. A curious feature is to be noted in the figure given by Gould (fig. 587), viz. that both the left and right third arms *bear an expanded apical portion*. The right is undoubtedly hectocotylized, but the left is figured from the dorsal aspect only. It is therefore possible that the expansion at the tip of this arm may be an error. If it is correct

* There is some divergence between the text and the figure in this respect. From the text the depth would be 17%, from the figure 27%.

and that arm is also hectocotylized, it will constitute an additional case of double hectocotylization (see p. 18).

The surface is coarsely "reticulated" (? covered with large irregular warts). The colour would seem to be characteristic, viz. a ground-colour of ochreous orange with blue "reflections" (? maculae) and transverse crescentic marks of dark brown on the arms and web.

Maximum size.—(?) 23½ in. (Gould).

Remarks.—This interesting form is only known from the original description. It may possibly represent an E. Pacific form of *O. macropus*, though the likeness to that species is not very fundamental. The curious expansion on the left third arm (? error) should be noted.

Gould makes the statement that the dorsal ends of the mantle-aperture are so coloured as to resemble a second pair of eyes. The resemblance may be quite accidental, or he may be referring to an ocellus. If the colour-patches referred to are "ocelli," the position which they occupy in this species is unique in the subfamily.

Octopus (Octopus) duplex, Hoyle.

(Text-fig. 15.)

Octopus duplex, Hoyle (1885, p. 226), *id.* (1886, p. 90, Pl. VII, fig. 5), Joubin (1894, p. 36), ? Appellöf (1898, p. 567), Pritchard and Gatliff (1898, p. 241); *Polypus duplex* ?, Berry (1917, p. 11, fig. 5).

Syntypes.—In Brit. Mus.

Specimens examined.—Two specimens (♂♀, the male immature) from Twofold Bay, S.E. Australia: 89.4.24.31–2. (Types.)

Distribution.—Twofold Bay, S.E. Australia (Hoyle); Amboina (Joubin); Ternate (Appellöf); off Maria Island, Tasmania, in 65 fathoms (Berry); Pt. Philipp, Victoria (Pritchard and Gatliff).

Description.—The mantle is broad and bursiform in the type, somewhat narrower in Berry's example (here known as D 3) and still narrower in Joubin's. The head of the latter is also narrower and in both cases the head is rather narrower than the body (63–52%). The mantle-aperture is rather narrow (B). The arms are short 76–68 (D 3). The order in D 3 is L 2431, R 2 = 431; in Joubin's female example it is 4231. The suckers are rather large in the type (14%). The web is subequal in the first four sectors and rather markedly shallower in the ventral. In D 3 E is rather larger than A. It is tolerably deep (23–26%) and is continued up the arms as a rather well-developed membrane. There are six filaments a side in each demibranch. The funnel-organ is not preserved. The funnel itself is narrow and tubular and is free for about one-third of its total length. In the male type specimen which is very small the hectocotylus is undeveloped. There is no spermatic groove at all and the ligula is undifferentiated, though the suckers are absent from the distal 8–10% of the length, as though foreshadowing the formation of a long narrow ligula. The sperm-groove is normal in Joubin's specimen. Appellöf's description is vague, but it seems that a differentiated ligula with laminae is present in his specimen. The radula of the type does not at all resemble that figured by Berry. (*a*) The rhachidian has

a symmetrical seriation (A); in Berry's figure it is shown as asymmetrical. (*b*) The first laterals differ in general shape. (*c*) The second laterals have a far more prominent keel in D 3, and (*d*) the third laterals have a much feebler and differently shaped base in the type. Hoyle states that the type specimen is smooth. Actually there are distinct traces of a granular sculpture, which is seen better in the young male. Berry finds faint traces of papillation in his specimen, and in Joubin's the skin is " garni de très petits pustules basses."

Maximum size.—100 mm. (Berry).

Remarks.—As Hoyle points out, this species presents no peculiar or distinctive features. All the known examples are small, averaging about 75 mm. over all. The larger type-specimen (♀) is sexually mature and its general facies may be regarded as that of an adult. With such a generalized type it is very difficult to be certain that it is not referable

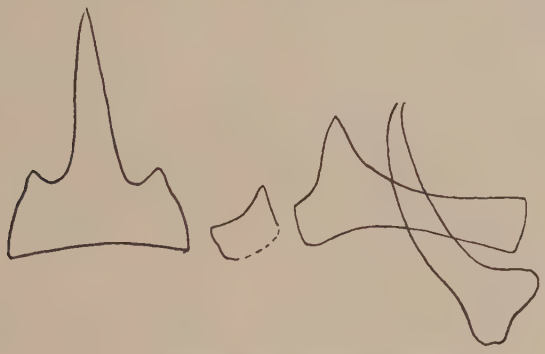


Fig. 15.—*Octopus duplex* (type). Radula.

to some other species, and yet I can find none with which I can with confidence identify it. *Octopus rugosus* is not unlike it; but the well-developed web in sector A, the rotund build and the character of the radula of *duplex* differentiate it from that species. The curious lack of any individual peculiarity noted above makes it very uncertain whether the identifications of Appellöf, Joubin and Berry are correct, and whether we should take the data from the latter into our description. Appellöf says that his Ternate specimen agrees in most aspects with Hoyle's, but, as he does not give any details, we cannot check his identification. Berry, who queries his own identification, gives full details and a figure of the radula. Such differences as occur between Berry's specimen and the types are noted above. Although some of these differences are fairly substantial (*e.g.* in shape of body and web, arm-length and radula) I am not prepared to object to Berry's diagnosis. The radula is indeed markedly different in the two specimens, but I do not think evidence of this kind is to be relied on without strong corroboration from the other organs.

Octopus (Octopus) oculifer, Hoyle.

Polypus oculifer, Hoyle (1904*a*, p. 14, Pl. 4, figs. 3–4).
Holotype.—In U.S. Nat. Mus., Washington.

Distribution.—Only known from the type locality, Charles Island, Galapagos Islands.

Description.—The single female type specimen is oblong in mantle-shape, but is only a little longer than broad. The very prominent eyes confer on the head a greater width than that of the body. The arms are in the order L,2.3.4.1.; R,2 = 3.1.4. They attain a maximum length of 78% (see below). The mantle-aperture is rather narrow (? B). The suckers are fairly large, but are not discontinuously enlarged. The web is not fully described; it is considerably deeper ventrally than dorsally, and it occupies nearly a third of the longest arm. The dorsal surface of the mantle, web and arm-bases is granular and the inner surface of the web is also finely granular. There are no cirrhi. The colour is dull violet (spirit), becoming ochreous below. Between the eyes and the bases of the lateral arms is an ocellus of the *O. membranaceus* type (a light centre surrounded by two dark rings separated by a light ring). Hoyle's description of the ocellus and his figure 4 (Pl. 4) are at variance, as the latter does not show the light centre mentioned in the text.

Maximum size.—" About 52 mm." (Hoyle). This figure is probably erroneous, cf. details in Hoyle (*l.c.*, p. 15).

Remarks.—Hoyle distinguishes this species from the other five species which have ocelli. As this specimen is itself very small (15 mm. in mantle-length), it is almost useless to discuss its relationships. It seems to have some affinity with *O. membranaceus*.

Octopus (Octopus) berenice, Gray.

(Plate II, fig. 1; text-fig. 16.)

Octopus berenice, Gray (1849, p. 11), Hoyle (1889, p. 221, as " insufficiently characterized ").
Holotype.—In Brit. Mus.
Specimen examined.—One ♀ from unknown locality: 1928.1.22.3. (old collection).

Distribution.—Unknown.

Description.—The type specimen is small, barely 18 mm. in mantle-length, and rather damaged and discoloured. Its body is rather ovoid, the head being narrower than the body. The arms of one side are in the order 3 = 2.4.1., and are about 78% of the total length. The suckers attain a maximum size of 16% of the mantle-length and are therefore to be reckoned very large for a female. The increase in size, however, is not abrupt. The sections of the web are subequal, but C is deeper than A and E. It attains a maximum depth of 18% of the arms, and is not prolonged up the arms. The anterior surface of the web and mantle are covered with numerous simple and multifid warts. The dorsum is

worn and damaged, but there is a lozenge-like pattern of four groups of warts. There are four large warts over each eye. The colour is very much spoilt by preservation and was not recorded by Gray. The funnel-base is very deeply incised and the locking edge is effectively divided into two. The funnel-organ is **W**-shaped; its exterior limbs are very slender and the dorsal angle very thick.

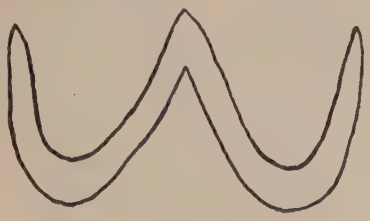


Fig. 16.—*Octopus berenice.* Funnel organ.

Maximum size.—86+mm. (Type.)

Remarks.—It is practically impossible to discuss this form with any profit, as the type is in such bad condition. It seems to have some affinity with *O. rugosus*, though for a young *rugosus* the web is very short. The web is actually more like that of *O. horridus*. The size and order of the arms differ from those of *O. horridus*, and the funnel-organ and locking ridge are unlike those of both *O. horridus* and *O. rugosus*.

Octopus (Octopus) hoeki, Joubin.

Octopus Hoeki, Joubin (1898, p. 24).
Holotype.—In R.M., Leiden.
Specimen seen.—One (♀) from Amboina (Type), R.M., Leiden.

Distribution.—Only known from the type locality, Amboina.

Description.—The type specimen is in very bad condition, the surface tissues being badly damaged and the specimen being otherwise mangled. The body is oval, the head very narrow (24%) and the eyes prominent. The width of the body is 40% of its length. The arms are in the order 3.2.4.1. or 3.4.2.1., and are very short (71%). The suckers are 9·2% of the mantle-length and therefore to be reckoned as small. The web has the formula D = C.B = E.A. and is 19% of the arms; it is prolonged up the arms as narrow membranes. The dimensions of the various sections are as follows: A, 18 mm.; B, 27 mm.; C, 32 mm.; D, 32 mm., and E, 26 mm. The funnel is free for $\frac{19}{27}$ of its length; it does not extend beyond the level of the eye. The funnel-organ is not preserved. The surface was originally covered with warts (not "smooth" (Joubin)), of which a few worn survivors remain on the type. The colour was originally described as "whitish except in the middle of the dorsum and head, where it is deep violet." Remnants of purple-coloured skin are still preserved. The skin was originally flaccid and the suckers were deeply sunk in the tissues. Joubin observed between the dorsal arms and the "moitié dorsal de la deuxième palmure (?)" a number of small pigmented organs.

Maximum size.—230 mm.

Remarks.—In general the type specimen recalls *Octopus vulgaris* except for the short arms. But it is in such a bad state of preservation that its true position cannot be decided.

Octopus (Octopus) herdmani, Hoyle.

Polypus herdmani, Hoyle (1904*b*, p. 187, Pl. 1), *id.* (1907*b*, p. 454), Massy (1916*a*, p. 206 (?)); *Octopus herdmani*, Winckworth (1926, p. 326).

Type specimen.—Not traced. (? Syntype.)

Specimens seen.—Three young examples (♂♀♀) from the University Museum, Liverpool (Nos. 224–6).

Distribution.—Galle (lagoon), Palk Bay, Periya and Cheval Paar and "pearl bank," Gulf of Manaar [Ceylon] (Hoyle, Winckworth, Massy); Zanzibar (Hoyle) in 10 fathoms. Only recorded in littoral stations.

Description.—There is some ambiguity attached to the records of this species which makes it somewhat difficult to decide which of the specimens described under this name are to be admitted into it and consequently what the exact characteristics of the species are. Thus Massy describes in some detail a small specimen measuring 12 mm. in mantle-length. She states that the ocelli consist of "a dark oval patch surrounded by a narrow lighter-coloured ring," and Winckworth describes the ocellus of his specimen as "a dark area surrounded by light and dark rings." Now Hoyle makes it quite plain that in the type the ocellus has a pale centre in addition to the pale outer ring, although in one of the young specimens (Hoyle, 1907*b*, Nos. 224–6) the ocellus has no light centre. We know that the ocellus varies (*e.g.* in *bimaculatus*, *v.* p. 80); but we are not entitled without further evidence to accept Massy's and Winckworth's specimens as examples of *herdmani*. Massy's specimen is obviously very young. There are not many features common to her description and that of Hoyle; but of those available the head and body proportions differ (Massy: mantle-width, index 66, head-width 75), and the arms are shorter in Massy's example (72%). Winckworth's specimens are not described in detail.

In the original description the body is "purse-shaped" and widest apically. The head is a good deal narrower than the body and the eyes are only moderately prominent. The arms are in the order 4 = 2.3.1., 3.2.4.1., and attain a maximum length of 78% of the total length * (Hoyle's figures for arm-, body- and total-length are mutually contradictory). The web is widest laterally and E and D is deeper than A and B. The web attains a depth of about 26% of the arm-length. The suckers are of moderate size and none of them are specially enlarged. The surface is wrinkled by (? accidental) folds and is covered by numerous and prominent warts, which are mainly elongate antero-posteriorly on the back. Four of these are arranged in a diamond pattern. There are no obvious ocular cirrhi. The colour is dull brownish grey, paler below. The ocelli have been described above. They are placed about a third of the way between the eye and the edge of the web, and are just over 13% of the mantle in length.

Maximum length.—(*a*) 550 mm. (? 451 mm.) (Hoyle). (*b*) 575 mm. (Winckworth). (? Identification.)

* This figure is obtained by adding Hoyle's "mantle-length" (95 mm.) to the maximum arm-length (356).

Variation.—Until the identity of Massy's and Winckworth's specimens is properly established it is not safe to discuss the variability of this species.

Remarks.—The proportion of the head and body, the length of the arms and web and the ocellus (though not the precise form of the latter) are highly suggestive of the common *O. cyanea* (see p. 94). Should Massy's and Winckworth's specimens, in which the eye-spot is simpler, be ultimately shown to be referable to this form, it would increase the likelihood that it is a form of *cyanea*. On the other hand the sculpture, colour and the depth of the web are distinctive, at least as described. Hoyle makes no mention of the dark stripes on the arms, which are so characteristic of *cyanea*. Furthermore, Hoyle's description of the ocellus does not suggest that it is like that of *cyanea*; though we must recall (1) the variability of ocelli in general, and (2) the fact that one of Hoyle's young specimens has a simple ocellus. However, as the type of this specimen cannot be traced, the only satisfactory means of deciding whether *herdmani* should be included in the synonymy of *cyanea* are not available.

Octopus (Octopus) vitiensis, Hoyle (? = **O. rugosus**).

Octopus vitiensis, Hoyle (1885, p. 226), *id.* (1886, p. 84, Pl. VII, figs. 6–8), Appellöf (1898, p. 563); *Polypus vitiensis*, Wülker (1913, p. 459).

Holotype.—In Brit. Mus.

Specimens examined.—One specimen (Type) (♀) from Kandavu, Fiji: 89.4.24.24. Found on reefs. (Two ♀♀ in Senckenberg Museum labelled "*vitiensis*" are referable to *O. cyanea*.)

Distribution.—Fiji (Hoyle); Ternate (Appellöf); (?) S.E. Celebes (Wülker).

Description (of the type specimen).—The body is rather oblong, becoming narrow towards the rounded apical extremity. The head is definitely wider than the body and the eyes are large and prominent. There is no "neck." The arms are in the order R, 2 = 3.1 = 4 (L mutilated) or 3.2.4.1., and are 72–73% of the total length. The web has the formula C.B = E.D.A., and is 33% of the arms in length. The suckers are rather large, 13% of the mantle-length, but are not specially enlarged in the male. The funnel is long and acutely pointed. The funnel-organ seems to have been **W**-shaped and to have had the outer limbs closely parallel to the inner. The hectocotylus is only known from a brief statement of Appellöf's that it is extraordinarily short. The surface is sparsely granulated with rather prominent tubercles. There is a large multifid cirrhus over each eye. The type specimen (in alcohol) is very much discoloured. According to Hoyle the original colour was very dark grey, almost black, above and on the outer surface of the arms, paler on the ventral surface and inner arms-surface.

Maximum size.—240 mm. (Wülker).

Remarks.—Hoyle (1886) stated that the type specimen of this species

somewhat resembled *O. tuberculatus* (= *O. rugosus*), but differed in the shortness of the arms, fewness of the cirrhi and in having the inner surface of its arms shagreened, "which last is its most distinctive peculiarity." It now appears that these features are not sufficient, even if taken collectively, to justify the separation of Hoyle's *vitiensis* from *rugosus*. The specimens obtained by Appellöf and Wülker are not described in any fullness, and such information as is added by them does not provide any stronger reasons for regarding *vitiensis* as distinct from *rugosus*. The chief characteristics of this form are set out on p. 42 and should be compared with those of *rugosus* (*l.c.*). The following extra data and observations are to be noted.

(1) Wülker's specimen is much larger than the type specimen, being 24 cm. long.

(2) The form of head and mantle are unlike that of any *rugosus* I have seen, the head being a good deal wider than the body, wider indeed than in *O. gardineri*, which *vitiensis* resembles very much in this respect. It is true that the type is very small (perhaps young) and that the head tends to be wider in young specimens, but in *vitiensis* it is abnormally wide and the width does not seem due to immaturity. Appellöf states that his specimens are diverse in form and that the males are more slender than the females. However, neither he nor Wülker comments on the actual proportions of the head.

(3) Wülker is in error when he says that the arms of his specimen are longer than in the type. The ratio in the type is $\frac{45 \times 100}{60} = 75$. In Wülker's specimens it is $\frac{175 \times 100}{240} = 72$.

(4) I agree with Wülker that the dorsal "Hautleisten" noted by Appellöf are probably adventitious.

(5) Wülker and Appellöf lay stress on the shortness of the web in sector A and on the whitish warts on the oral surface of the web and arms as specially characteristic of this species. On the contrary I have, however, found both these features in examples of *O. rugosus*.

(6) The hectocotylus is only known from an imperfectly preserved specimen of Appellöf's, and seems to be remarkably short.

On the whole it seems better for the time being to treat this as a separate species. It is undoubtedly very like *O. rugosus*; but the proportions of the mantle and head, the shape of the funnel and probably of the funnel-organ are different. It is a little unfortunate that neither Appellöf nor Wülker gave full particulars of their specimens and only very few measurements. The type is a young specimen only 60 mm. long, and Wülker's example is four times as large. As there is some doubt as to the status of Hoyle's species, it is most unfortunate that we do not possess full particulars of the later recorded specimens. When examining the collection of Octopoda in the Senckenberg collection I could not find Wülker's "*vitiensis*." Berry (1914*b*) compares his *Polypus oliveri* from the Kermadec Islands with this species.

Octopus (Octopus) microphthalmus, Goodrich.

(Text-fig. 17.)

Octopus microphthalmus, Goodrich (1896, p. 20, Pl. V, figs. 83–84); *Polypus microphthalmus*, Massy (1916A, p. 205).

Holotype.—In the Indian Museum, Calcutta.

Specimens examined.—One ♀ from Port Blair, Andamans, $M^{3}\frac{6}{1}\frac{1}{}$, Indian Museum (Type).

Distribution.—Port Blair (Andaman Islands), (Goodrich); Karnaphuli River (Chittagong, Bengal), (Massy).

Description.—The body is very characteristic. It is cylindrical and rather wider in the apical region than anteriorly. The head is narrower than the body and the eyes are very small. There is no " neck." The arms are short, 69–72% of the total length. The order is very variable. In the type the dorsal pairs are longer than the ventral; in Massy's specimens the ventral pairs are longer. The arms are rounded and the suckers are widely spaced and (in the type) scarcely prominent. At about half-way along the arm they alternate very widely and soon become almost uniserial. The diameter of the suckers is very small and scarcely exceeds 6% of the mantle-length. The web in the type has the formula B.A.C.D.E., B and A being subequal. There is some divergence between Massy's specimens and the type, as the web in the latter is 20% of the arm (Goodrich's figures corrected) and in the former it is about a third (33%) of the arms. The web is poorly developed and is not continued up the arms. The funnel is free for half its length in Massy's specimen; but in the type is largely adherent and only free for about a quarter of the length. The funnel-organ was not found by Massy. In the type it is badly preserved. There are two single median plates, long, narrow and pointed at each end. They may be the original organ and, if so, constitute a very remarkable type. But, as the surface is obviously in poor condition, I do not feel certain that the complete organ is represented. There seem to be eight filaments in each demibranch, the distal four being very much reduced. The distal oviduct is stout and cylindrical and much longer than the proximal. Goodrich mentions no sculpture and alludes to the " smooth cylindrical shape." Massy specifically states that her specimens are " quite smooth everywhere." Examination of the type reveals the presence on the anterior part of the head and web of numerous small pustules or blisters which may be artefacts, and also of a smaller number of low, simple warts. The colour of the type (in alcohol) is pale olive dorsally speckled with brown. When Goodrich examined the specimen he found it " yellowish brown " in ground-colour. Massy's specimens were white speckled with dark chromatophores " which are most numerous on the dorsal surface . . . where they are occasionally aggregated into elongate grey smears." Larger chromatophores were

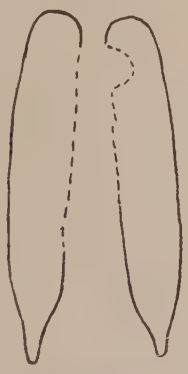


Fig. 17.—*Octopus microphthalmus.* Funnel organ. × 6.

present on the mantle in Massy's specimens and pass up the arms in two rows as in forms of *Macrotritopus*, etc. Massy comments on the tendency for the skin of the oral surface to form superficial pouches. I have observed this in other species, e.g. *O. australis*; but I think it is merely an effect of contraction.

Maximum size.—About 117 mm. [Massy].

Remarks.—This form is easily recognizable by the shape of the mantle, the short arms, minute eyes and delicate sculpture. Massy's comparison with *elegans*, Brock, *fusiformis*, Brock, and *pricei*, Berry, are scarcely justifiable. A better knowledge of the status of this form is dependent on obtaining specimens in which the funnel-organ is better preserved. At present that organ appears to be unlike that of any species in the genus.

Octopus (Octopus) cephea, Gray.

(Plate V, fig. 2.)

Octopus cephea, Gray (1849, p. 15), Hoyle (1889, p. 221, " insufficiently characterized "); ? *Polypus cephaea*, Smith (1907, p. 407).

Holotype.—In Brit. Mus.

Specimens examined.—One [Type] (♀) from unknown locality: 1928.2.2.1 (old collection). (?) One (♂) from Japan: 1907.9.11.1.

Distribution.—Unknown, (?) Japan.

Description.—The body is distinctly oblong, the head being much narrower than the body. The arms are in the order 3.2.4.1., and being 83% of the total length may be considered as long. The suckers attain a maximum diameter of 16% of the mantle-length, and there is a fairly abrupt increase in their size in the male specimen. The web is of the type C.D.B.E.A. The disparity between the largest and smallest sectors is very marked (50% of the body length), and the maximum depth is 28% of the arms. The surface of the body is covered with obsolete warts which originally must have been rather broad, low and closely apposed. The sculpture certainly is reminiscent of that of *Octopus vulgaris*, though the warts are less irregular. The colour in both specimens is spoilt by bad preservation. The mantle-aperture is rather narrow (type B). The funnel-organ is not preserved. The number of filaments in each demibranch is uncertain, but seems to be 7–8. The hectocotylus is imperfectly known, as the male specimen is very badly preserved.

The arms in the male specimen are *all* bifurcate, as described by Smith (1907).

Maximum size.—(?).

Remarks.—It is impossible to decide whether this is a distinct species or referable to one of the better-known forms. The type specimen is in a very bad condition, and the example tentatively referred here to the same species and so treated by E. A. Smith is only a dried skin. The species has been identified with *Octopus tetricus*, Gould, by Smith (MS.). Gray himself commented on its resemblance to *Octopus vulgaris*. I do not think it can be referred to *tetricus* (though there is a certain likeness between the two), as the form and size of the web and the sculpture are different. *O. cephea* is also a good deal narrower. As to its identity with *Octopus vulgaris* I am less certain. It is possible that it should be treated as a form of that species, though it presents a combination of extreme *vulgaris* characters.

Octopus (Octopus) horridus, Orbigny (? Audouin).

(Text-figs. 18–19.)

Octopus horridus, Orbigny (1826, p. 144), Audouin (in Savigny, 1826, p. 10, Pl. 1, fig. 2), Ehrenberg (1828, *a''*), Orbigny (1840, p. 51, Pl. 7, fig. 3); "*Octopus fimbriatus*, Rüppell," *id.* (*l.c.*, p. 64); *Octopus horridus*, Gray (1849, p. 10); *Octopus argus*, Krauss (1848, p. 132, Pl. VI, fig. 26); *Polypus aculeatus*, Hoyle (1904*b*, p. 194, Pl. II, figs. 10–13 in error as *P. aculeatus*); *Polypus horridus*, *id.* (1905, p. 978), *id.* (1907*a*, p. 37), *id.* (1907*b*, p. 454), Weindl (1912, p. 270), Wülker (1920, p. 50), Robson (1921, p. 439, text-fig. 5); *Octopus horridus*, *id.* (1925, p. 105), Winckworth (1926, p. 327), Robson (1927*a*, p. 322, text-fig. 78).

Type specimen.—In Senck. Inst. ("*O. fimbriatus*," Rüppell). (? Holotype.)

Specimens examined.

(*a*) In Brit. Mus.

Three (2 ♀, 1 ♂) from Port Taufiq, Toussoum and Kabret, Suez Canal: 1926. 4.8.2–4. One (♀) from the Red Sea (Rüppell): 1928.1.28.1 (old collection). Two (♂) from Amirante Island, Indian Ocean: 1921.9.14.269,274.

(*b*) In M.H.N., Paris.

One specimen (♀) from Suez (Vaillant), (type of "*O. macrophthalmus*," de Rochebrune, MS.).

(*c*) In Senck. Inst., Frankfurt a/M.

Three from Suez (Rüppell: including type of "*O. fimbriatus*"). Two (♀♂) from Suez (Bannwarth).

(*d*) In Z.M., Berlin.

Four (2 ♂, 2 ♀) from the Red Sea (Hemprich).

Distribution.—Suez Canal (Robson); Red Sea (Orbigny [Egyptian Coast], Gray, Weindl, Wülker [Suez], Hoyle [Suez, Khor Dongola, Suakim]); Zanzibar (Hoyle); South Africa (Krauss); Indian Ocean (Robson [Amirante]), Hoyle [Hulule and Male Atoll]); Ceylon (Hoyle, Winckworth).

This is a littoral form usually taken in water of a few fathoms. Robson (1921) records it at 80 fathoms. It seems to favour reefs, and has been taken in the crevices of coral (Hoyle, 1907*a*). It is curious that this species, though widely distributed and evidently common in the West and Central Indian Ocean, has not passed east of Ceylon and the Maldives.

Description.—The shape of the body varies very considerably and may be more or less quadrangular or ovoid. The arms are long, constituting 80–85% of the total length. The fourth arms are regularly the longest, and the formula 4.3.2.1. occurs very frequently. The suckers are rather large, but are not abruptly enlarged in the male. The web is very variable in shape. It tends to have the formula C = D = E.B.A. It is uniformly shallow and never exceeds 15% of the arms in depth. The surface is conspicuously ornamented with white circular patches which stand out against the reddish-purple ground-colour. In the centre of each patch is a small or large cirrhus. This feature is sometimes obscured by a general darkening of the ground-colour, which in these

circumstances tends to pass into the patches. Very exceptionally the whole surface is uniformly dark brown (cf. Robson, 1927*a*, Hoyle, 1907, 1904, and specimen (No. 38) in the Berlin Museum). Nevertheless, the reticulate pattern caused by the patches is, except in one or two exceptional cases, always perceptible, especially on the arms. The mantle-aperture is rather narrow (B). The number of filaments in each demibranch is surprisingly low, viz. about 6. The funnel is free for about $\frac{6}{15}$ of its length, and the funnel-organ is **W**-shaped. The pallial septum is very short and does not exceed 18% of the mantle-length. The radula has a rhachidian tooth with an A 3–4 seriation. Some variation occurs in the first lateral. In one of the Museum specimens (Suez) it is far wider than in the other Suez specimens, in which respect it agrees with the Amirante specimen figured by Robson (1921, p. 439). The second lateral is more constant, though the depth of the basal plate varies somewhat. This tooth has no entocone. The third laterals are regularly long, slender and have rather small bases. The marginals are poorly developed. The hectocotylized arm is rather shorter than its

Fig. 18.—*Octopus horridus.* Hectocotylus. × 8.

Fig. 19.—*Octopus horridus.* Penis.

fellow. Its ligula is small, being about 3·9% of the arm in length. The ligular groove is narrow and deep, and there is a marked transverse groove below the calamus. The diverticulum of the penis is small. The distal part of the oviduct is very long. In one female specimen the oviducal gland was very large, in the others very small.

Maximum length.—176 mm. (Brit. Mus.).

Variation.—Generally considered, this species is remarkably homogeneous. The specimens which I have had before me and the description given by previous students all agree very regularly in the principal external characters, especially in the colour-pattern. As these records and specimens come from areas as far apart as the Suez Canal, South Africa and Ceylon, a very considerable amount of uniformity is indicated. So far the species has not been recorded from East of Ceylon; but some equivocal forms from the Gulf of Siam (Robson, MS.) are possibly referable to it. The two most striking sources of variation are in the form of the body and the colour. (1) The body varies from a curious and characteristic pyriform shape with an apical point to an almost square shape. Some details and discussion on this point have already been given (Robson, 1927*a*, p. 323). (2) The variation in colour is described above. The most striking feature is the occurrence of homogeneous dark purple or blackish forms.

Remarks.—Orbigny and Audouin applied the same name to this species in the same year (1826). Orbigny's date of publication has been fixed by Mr. C. D. Sherborn (MS.) as in January–February of that year. The exact date of Audouin's " explication " of the unfortunate Savigny's plates in the " Exploration de l'Égypte " cannot be ascertained (see Sherborn, 1897, p. 287). Orbigny apparently had not seen any specimens, but relied on Savigny's figures which must have been sent to him in advance. I ought to point out that Orbigny's description is very defective and might be applied to several species, and that he quotes Savigny's figure, which in all probability was not published at the time of his own publication. Had Audouin (*l.c.*) not identified his *horridus* with that of Orbigny, it would have been necessary to find a new name for it, as Orbigny's description is so vague. There have been no nomenclatorial complications since 1826. *Octopus fimbriatus*, a MS. name of Rüppell, was applied by Orbigny to specimens (? from the Red Sea) reported and described in a letter sent to him by de Haan. I have examined the type specimen of " *fimbriatus* " in the Senckenberg Institute (Wülker, 1920, p. 50). It is obviously a specimen of Orbigny's *horridus*, and according to a statement on the label is actually the specimen figured by Audouin under that name. If this specimen was the one described by de Haan to Orbigny, the latter has to his credit the singular achievement of describing two different species from one and the same type ! Orbigny described his *horridus* from the figure prepared by Savigny and described by Audouin and (?) circulated before publication (cf. Orbigny, *l.c.*, p. 52). Logically it would follow that Audouin's specimen (the specimen in the Senckenberg Museum named " *fimbriatus* " by Rüppell and stated (on the label) to have been figured in Savigny's " Égypte ") is the type. Such a circumstance, the publication of a first description based on a specimen not seen by the author, is happily rare.

Octopus (Octopus) globosus, Appellöf.

(Text-fig. 20.)

Octopus globosus, Appellöf (1886, p. 7, Pl. 1, figs. 4–5); *Octopus rugosus*, Ortmann (1891, p. 669; pars = *globosus*, fide Massy, 1916*a*, p. 202); *Octopus globosus*, Goodrich (1896, p. 19, Pl. V, fig. 81), Joubin (1897*a*, p. 98), Appellöf (1898, p. 565) (?)); *Polypus globosus*, Berry (1912, p. 388), Massy (1916A, p. 202); *Octopus globosus*, (?), Winckworth (1926, p. 326).

Type specimen.—In the Zoological Museum, Uppsala University (? Holotype).

Distribution.—Japan ? loc. (Appellöf); Nagasaki (Joubin); Straits of Malacca, Nicobar Islands, Mergui (Goodrich); Ceylon (Ortmann, Goodrich, Winckworth); Bombay (Goodrich, Massy); Ternate (Appellöf); Gopalpore [? Madras], (Massy). Apparently a littoral form.

Description.—The body is distinctly globular and the head is rather wide, but usually narrower than the body. The arms are rather long, viz. about 80% of the total length. They are usually in the order 2.4.1.3. A few suckers are markedly enlarged in the male. The web appears to

be more or less equal in all the sectors, and is continued up the arms as lateral membranes. The surface in the type specimen is slightly tuberculate. The sculpture of Massy's specimen is similar. The colour is reddish-brown in one example inclined in the other to a violet reticulation ("anstrykning"). The mantle-aperture seems to be variable. It is widely open in the type, and "small" in Massy's and Winckworth's specimens. The funnel and funnel-organ are not described in detail. The hectocotylized arm is rather shorter than its fellow. The very small ligula has been figured by Goodrich, and those of Massy's two adult specimens resemble that figured.

Fig. 20.—*Octopus globosus.* Hectocotylus. (After Goodrich.)

Maximum size.—? 175 * mm. (Appellöf); ? 350 mm. (Joubin ("jeune" !)); 192 mm. (Winckworth).

Remarks.—The status of this species is very obscure. Ortmann (1891) regards it as the same as *Octopus rugosus*. Massy (1916A) considers that Ortmann's *rugosus* contained some examples at least of *globosus*, though she evidently thinks that the latter is specifically distinct. Appellöf (1898) objects to Ortmann's opinion on the grounds (*a*) that sector A of the web of *globosus* is not deeply incised, and (*b*) that the sharp distinction between the colour of [the ventral and lateral surfaces of] the arms is not found in his species. I have not had access to the type of the species, and until Appellöf's description is amplified I consider it wiser to treat the species as distinct. In general the available details give us the impression of a form allied to *rugosus*, but different in (1) its equally developed web, (2) less definitely granular surface. The hectocotylus, as figured by Goodrich, might, however, pass for that of *rugosus*, and Appellöf's remark that one of his specimens "hade ofvantill en mera *violett anstrykning*" is suggestive of the dark reticulation of *rugosus*. It must not be forgotten that Appellöf's type specimens were only 35 mm. long in the body, and his Ternate examples and those of Massy were much smaller. It is by no means certain that the latter two series are referable to *globosus*. Winckworth's adult Singhalese specimens are larger than the type; but they are only tentatively referred to this species.

Octopus (Octopus) cyanea, Gray.

(Text-figs. 21–23.)

Octopus cyanea, Gray (1849, p. 15); *Octopus marmoratus*, Hoyle (1885, p. 227), *id.* (1886, p. 85, Pl. VI), Brock (1887, pp. 610–11), Ortmann (1891, p. 671; ? *Octopus cyanea*, Brazier (1892, p. 77); *Octopus marmoratus*, Joubin (1894, p. 35); *Octopus horsti*, Joubin (1898, p. 23); *Polypus marmoratus*, Hoyle (1905, p. 978); *Polypus horsti*, *id.* (1907*a*, p. 38), *id.* (1907*b*, p. 451); *Polypus marmoratus*, Berry (1909, p. 418); ? *Polypus horsti*, Weindl (1912, p. 270); *Polypus marmoratus*, Wülker (1913, p. 457), Berry (1914*a*, p. 291, Pls. XLV, XLVIII, fig. 6); ? *Polypus cyanea*, Massy (1916A, p. 195); *Polypus fontanianus* (in error), Robson

* Calculated from Appellöf's figure (pl. 1, f. 4).

(1920, p. 437, Pl. 66, fig. 5*a–e*); *Polypus horsti*, Wülker (1920, p. 51); ? *Octopus glaber*, Wülker (1920, p. 51, *non* Rüppell MS.).

Syntypes.—In Brit. Mus.

Specimens seen.

(*a*) In Brit. Mus.

Two (♂♀) from Honolulu : 1889.4.24.25–26. (Type of *marmoratus*.) One (♀) from Coetivy : 1921.9.14.267. One (♀) from Madras : 1909.5.7.6. One (♀) from Xmas Island : 1909.5.7.6. One (♀) from Xmas Island : 1899.5.26.14. One (♂) from " Coasts of New Holland " : 1928.2.4.1. (old collection) (Type). Three (♂♀♀) from Seychelles : 69.12.3.1.

(*b*) In Senck. Inst., Frankfurt a/M.

One (♀) = *O. glaber*, Rüppell (Type). One (? sex) from Rimatara, " Austr. Is." (Wolf, 1909).

(*c*) In Z.M., Berlin.

Two (♀♀) from Mauritius.

(*d*) In R.M., Leiden.

One (? sex) from the Red Sea, type of *O. horsti*, Joubin.

Distribution.—Honolulu, reefs (Hoyle); Oahu and Hilo, Hawaii (Berry); Rotuma, Fiji (Hoyle); Rimatara, Austral Islands, Buka and Stewart Islands, Solomon Islands (Wülker); Amboina (Joubin); Madras (British Museum); Coetivy Atoll, Indian Ocean (Robson); Ceylon (Ortmann); Suakim (Hoyle); Djeddah (Joubin); Zanzibar (Hoyle); Red Sea (Rüppell, Wülker); Australia (Gray, Brazier ?); Akyab, Burma (Massy).

Description.—The body is rather variable and evidently is most usually " rounded pyriform " (Berry). It may be bursiform (Brit. Mus.) or elongate-oblong (*ib.*). The head is rather small and is more constant in its proportions (about half the length of the mantle in width) than the visceral sac. The arms are rather long (78–83%) and very variable in order. They are, as Berry suggests, subequal, or at all events rarely differ by more than 30 mm. in length. The fourth is, I think, usually the longest. In the male the suckers are slightly enlarged on each arm at the level of the edge of the web. The mantle-aperture is moderately wide (B, B–C). The web is broadest laterally, and usually has the formula C.D.B.A.E. The dorsal sector is usually deeper than the ventral; but in three of Berry's specimens they are equal in depth, and in one case the sizes are A = 6 + mm., E = 8 mm. Berry states that it is about equal all round ; but this is not true of the type, and other specimens. The larger type specimen has a disparity index of 36%. The web on the whole is low (17(? 11)–24% of the arms). The skin is usually smooth (Joubin, 1898); but it is often so heavily wrinkled (no doubt due to preservation) that it attains a kind of rough " matt " texture, and in the larger type specimen is almost scaly. The surface is often traversed by meandering seams, which in older specimens produces the scaly effect just mentioned. The dorsal surface in addition almost invariably bears a few large tubercles, which are sometimes longitudinally extended. There is also a supraocular cirrhus generally present, which, as in one of Hoyle's Suakim specimens, may be accompanied by subordinate tubercles. The surface is mainly of a warm ochreous red suffused and

maculated with purple, which may be very deep so as to render the animal homogeneously blackish or deep livid (in preservatives). Sometimes the maculations are fine, and in certain cases are represented by reticulate lines (*e.g.* in the smaller type specimen. Below the eye and between it and the base of the third and fourth arms is an ocellus which is usually $\frac{1}{7}$ to $\frac{1}{8}$ of the mantle in length. It occurs in the following phases.

(1) Simple homogeneous dark purple spot (British Museum, No. 2).
(2) Simple homogeneous dark purple spot surrounded by an ill-defined pale ring (British Museum, Nos. 4 and 3; Berry; Hoyle).
(3) Eye-spot surrounded by pale ring and irregular outer dark ring (British Museum, type).

The ocellus is often obscured by the junction of the intensely dark purple patches. The arms are decorated by a series of irregular dashes

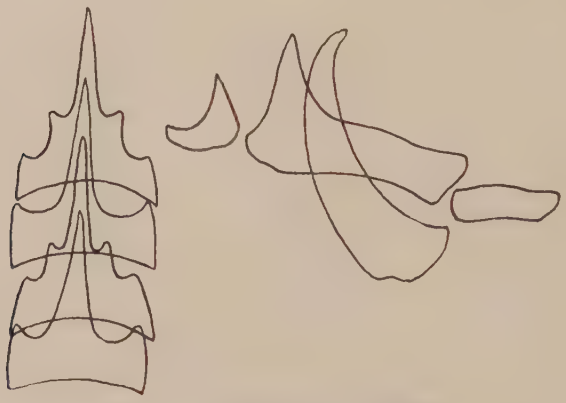


Fig. 21.—*Octopus cyanea*. Radula.

of colour on the ventral side of the rows of suckers, one dash lying between adjacent suckers. This has been figured by Hoyle (1907). It is very interesting and important to notice that this occurs *only on the ventral side of the arms*. This pattern is very variable in (*a*) the shape of the spots, and (*b*) their occurrence. They also tend to become confluent and to form a simple dark line (British Museum, No. 3), or to be obscured by the general deepening of the colour. The funnel is rather small, narrowly conical and is free for about half its length. The funnel-organ is figured by Berry (1914*a*, fig. 291), and the shape of the organ shown there is more or less similar to that seen in our specimens. The organ is small and rather clumsy; the limbs are thick, the outer ones being rather shorter than the median and acutely pointed distally. There are about ten filaments in each demibranch. The characteristic radula has been figured by Hoyle (1907*b*, p. 452, as *Octopus horsti*) and by Robson (1921, Pl. 61, fig. 5) as *Polypus fontanianus*). The rhachidian has an A_{2-3} seriation, the first lateral has a remarkably high cusp and a narrow base, the second lateral has neither heel nor ectocone. The third laterals are thick and moderately curved. The hectocotylus is very small and

ranges from 0·4–1·4% of the length of the arm. (In a specimen identified with some doubt by Joubin (*l.c.*) it is 4·1–5·5%.) The ligula is figured by Berry (1914*a*, Pl. XLVIII, fig. 6) and Hoyle (1886, Pl. VI; 1907*a*, fig. 128). There is a poorly developed calamus, a moderate central groove of the ligula, and the latter is marked by about ten weak laminae. The penis is long, straight and narrow. There is a very small globular appendix.

Maximum size.—630 mm. (Hoyle).

Habits.—This littoral species attains a considerable size, one of the type specimens being over two feet long. Berry states that in the Hawaiian Islands it is abundant on the reefs, and " is one of the most important of the species used for food." It is noteworthy that at the western extremity of its range it is also a reef-inhabiting form.

Variation.—The extent of variation in the chief features is indicated on pp. 96 and 98. There seem to be no very marked local types. Berry mentions four young specimens (" assumed to be referable here ")

Fig. 22.—*Octopus cyanea.* Penis. × 2·7.

Fig. 23.—*Octopus cyanea.* Hectocotylus. × 4·5. (After Hoyle, etc.)

that have no ocellus. The variation of the ocellus and of the arm-patches is substantial; also the dark marbling may become so much developed as to make the surface almost entirely black.

Remarks.—It was with very great surprise that, on comparing the type of Gray's *cyanea* with that of Hoyle's *marmoratus* and with other specimens agreeing with the latter, I found them almost identical. The type of Gray's species resembles in all essential details (including the ocellus and characteristic zebra-like markings on the ventral side of the arms) forms at present treated as " *marmoratus*," as defined by Berry (*l.c.*). The details of the structure, etc., of Gray's type are given as an addendum to this section (p. 98) and should be compared with the data on p. 44. This is a very variable and widely ranging species, and it is not yet clear how far all the forms attributed to it should bear the name. Nevertheless, it seems to be characterized by several more or less constantly associated characters, of which a simple ocellus and a series of intercotyledonary colour-stripes (" zébrure ") down the ventral surface of the arm are the most striking and most constantly associated. I have no doubt whatever that Joubin's *Octopus horsti* is a synonym. Wülker

(1920, p. 51) suggested that *horsti* and *marmoratus* are varieties of a "Stammform." *Horsti* was not at all fully described, but after seeing the type specimen I am convinced that it is identical with Gray's species. I agree with Hoyle that this species is closely related to *Octopus bimaculatus*, Verrill. The latter is certainly an Eastern Pacific offshoot from a common stock; but it is, as Hoyle suggests, distinct (see p. 80). As for Ortmann's suggestion (*l.c.*) that *marmoratus* [= *cyanea*] is identical with Eydoux and Souleyet's *hawaiiensis*, I see no grounds in the description for this opinion. The latter is very small (20 mm. mantle-length), and some of its characters may be juvenile. Even so, it offers no real points of resemblance, and the striking colour-features of *marmoratus* are not mentioned by Eydoux and Souleyet. The identity of Joubin's Amboina specimen is very doubtful. Its very short arms (62%) and the longer ligula render it likely that it is referable to a distinct species.

Gray's type of *Octopus cyanea*.

Mantle-length.	Width-index.	Head, width-index.	Arms.	Arms %.	Gills.	Suckers.	Web.	Depth of Web.	Dis-parity.	Hecto-cotylus.
112	63%	48%	4.3 = 2.1	83% B	9–10	12%	DCEBA	17%	33%	1%

The surface is smooth, though there are faint traces of a few obsolete dorsal warts. The colour is a homogeneous dark purple above, lighter below. There is a well-marked ocellus consisting of a dark oval centre surrounded by a light area, and finally by a rather irregular outer dark ring. The ventral side of the arms is ornamented by regular *separate* patches of purple.

Octopus (Octopus) cyanea var. **gracilis** n. var.

Holotype.—In Brit. Mus.

Specimen seen.—One (♀) from Madras: 1907.9.28.1.

Distribution.—Madras (only known from the type locality).

Description.—This very well-marked form differs from the typical representatives of the species in (1) the very narrow oblong mantle, the width-length index of which is 46, (2) the marked confluence of the ventral spots on the arms to form an unbroken and sinuous line. The arms are very attenuated (? accidental), the funnel is freer, and the eyes are more prominent than is usual in this species.

Maximum size.—310 ± mm.

Octopus (Octopus) tetricus, Gould.

(Text-figs. 24–26.)

Octopus boscii, Lesueur, etc., Gray (1849, p. 12, see ph. 100, 128); *Octopus tetricus*, Gould (1852, p. 474, fig. 588), Brazier (1892, p. 5); ? *Octopus boscii*, Joubin (1894, p. 32 (pars)); ? *Polypus boscii*, Hedley (1916, p. 22 (pars)); *Polypus variolatus*, de Blv. (Berry, 1918, p. 278, in error).

Type specimen.—In U.S.N.M., Washington. (? Holotype.)

Specimen seen.—One (♂) from "New Holland": 1927.8.30.1. (old collection).

Distribution.—"New Holland" (Gray); Sydney (Gould, Brazier, Hedley); ? Amboina (Joubin).

Description.—The body is oblong with a rather narrow head. The arms are long, 81–86% of the total length. The suckers are rather

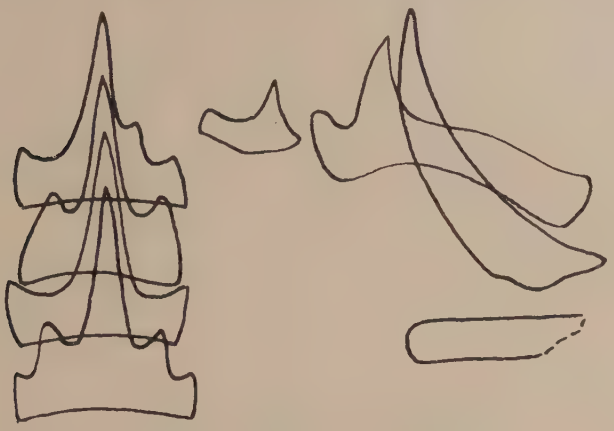


Fig. 24.—*Octopus tetricus.* Radula.

large, but they are not discontinuously enlarged in the male. The web is of the type C.D.A.B.E., and is 22% of the arms in length. The disparity-index is rather high, viz. 26%, sector E being noticeably smaller than the rest. The surface is covered all over with rosette-like tubercles which are far more conical than in *Octopus pallida*, the central knob

Fig. 25.—*Octopus tetricus.* Penis. × 3.

Fig. 26.—*Octopus tetricus.* Hectocotylus. × 7.

being high and reaching above the peripheral processes of the tubercle. The mantle-aperture is rather wide (B–C). There are 9–10 filaments in each demibranch. The funnel is free for about a half of its length. The funnel-organ is W-shaped. The radula has a rhachidian tooth with a very irregular A_{3-5} seriation. The adlateral is very unlike that of *pallida*, as it has a marked external heel. The second lateral has a strong entocone. The third laterals are broad, curved and very acute. The hecto-

cotylized arm is shorter than its fellow. Its ligula is very small with an index of 1·5%; it is leaf-shaped and has a wide shallow median groove.

Maximum size.—? 18½ in. (Gould).

Remarks.—In 1849 Gray briefly described an Octopod which he identified (see p. 126) with the *Octopus boscii* of earlier authors. None of the forms previously alluded to under this name is recognizable, and the name consequently cannot be applied to Gray's (recognizable) species. Gould's *tetricus* described three years later is plainly identical with Gray's *boscii* (see below). The type of the latter resembles Gould's *tetricus*, and not the form subsequently described as *O. boscii* var. *pallida* by Hoyle and *O. variolatus*, Blainville, by Berry. Gray's type agrees with *tetricus* in having long arms ("*boscii*" 81%, *tetricus* 86%), a shortish web ("*boscii*" 22%, *tetricus* about 18%), oval body and narrow head ("*boscii*," body index 72%, head 47; *tetricus* body 56, head 35), and fairly wide suckers ("*boscii*" 14%, *tetricus* 19%). The sculpture is not described in detail by Gould, and there are no other details given.

On the other hand, *tetricus* (including type of "*boscii*," Gray) differs from *pallida*, Hoyle, as defined on p. 127 in certain substantial respects. They are as follows: (1) The arms are a good deal longer in *tetricus*. (2) The web is of a quite different pattern in the two forms. (3) The funnel-organ is double in *pallida*, single in *tetricus*. (4) The radula. While Berry's figure of the radula of *pallida* (*l.c.*, fig. 63) is rather unlike that of the type, and we might be inclined to discount the difference between *pallida* and *tetricus* in this character, I am inclined to think that those differences are due to accidental causes such as defective orientation. On the other hand, the *tetricus* radula, unlike Berry's specimen of *pallida* and the type of the latter, has a bicuspid second lateral and the admedian has a marked external heel. (5) The sculpture is plainly alike in the two species, but while the rosette-like tubercles in *tetricus* have a high centre, those on *pallida* have a low one, and the whole tubercle is flatter and more neat. Nevertheless, intermediate types of tubercle occur in each. (6) The septum is longer in *pallida* than it is in *tetricus*, being 28% as against 15%. (7) The ligula is both very much shorter in *tetricus* and of a different pattern (cf. fig. 26). (8) The suckers in the Hoyle–Berry species range from 8–12%, while that of *tetricus* range from 14–19%. The relationship between these forms is very interesting. No one seeing the differences between the type of "*boscii*" and the Hoyle–Berry (*pallida*) form would hesitate to declare that they should be treated as specifically distinct. Nevertheless, from Berry's (1918) data it is plain that the body-form of *pallida* is sometimes ovoid, and thus more like *tetricus*, while such differences as exist between the two kinds of sculpture are possibly due to differences in preservation. It is very remarkable that the only forms of *Octopus* that have this unique type of sculpture fully developed should be so dissimilar in other respects.

Octopus (Octopus) oliveri, Berry.

Polypus oliveri, Berry (1914*b*, p. 136), Oliver (1915, pp. 560, 564), Berry (1916, p. 49, Pl. VI, fig. 2).

Holotype.—? In the Dominion Museum, Wellington, New Zealand.

Distribution.—Sunday Island, Kermadec Islands.

Description.—The body is plump and of " rounded pyriform " shape. In Berry's cotype the width exceeds the apex-eye length (taking the latter as about 35 mm. (40 less 5)). It is broadest posteriorly. The head is short and markedly narrower than the body There is a weak neck, and the eyes are conspicuous. The pallial aperture is moderate (B), and the funnel extends about half-way to the edge of the web. The arms are short (75%) and subequal, the lateral pairs being slightly longer. They are stout and taper rapidly. The suckers do not appear to be conspicuously enlarged. The web seems to be of the pattern C ? = D ? = B > A > E, and is less than 25% of the maximum arm-length. The arms are provided with lateral membranes. The radula, funnel-organ and internal and external genitalia are unknown. The dorsal surface is ornamented by " numerous low rough conical tubercles." The skin between these is either smooth or finely papillose. The sculpture is found on the inner surface of the web. There are no noticeable supra-ocular cirrhi. The colour is " dark slate," somewhat lighter below. The inner surfaces of the suckers are light brown " sometimes shading to cream."

Maximum size.—190 mm.

Remarks.—This species is known only by two female examples. According to Oliver (*l.c.*, p. 564), it is found in the Sargassum Belt and may be regarded as littoral, probably intertidal. As Berry rightly remarks (1914*b*, p. 137), it is not in any way related to the other native Kermadec Octopod, *Pinnoctopus* (?) *kermadecensis*. Its immediate relationship is obscure. Berry rightly compares it with *Octopus vitiensis*, and I have followed him in including it in the same group. The narrow pallial aperture and shallow web distinguish it from that species, and, combined with the short arms and the fact that sector A of the web is deeper than E, tend to make it rather unlike the majority of the *vulgaris*-like group.

B. Group of **Octopus macropus.**

(a) Subgroup of **Octopus macropus.**

Octopus (Octopus) macropus, Risso.

(Text-figs. 27–30.)

Octopus Lechenaultii, cuvierii, Orbigny (1826, plates only); ? *Octopus granosus,* Blainville (1826 (September),* p. 186); *Octopus macropus,* Risso (1826 (November),* p. 3), Wagner (1829, p. 387); " Polpo rossastro," delle Chiaje (1830, p. 40); *Octopus macropus, id.* (*l.c.*, p. 56); *Octopus macropodus,* Sangiovanni (1829, p. 319); *Octopus macropus,* Rang (1837, p. 61); *Octopus cuvieri,* Orbigny (1840, p. 18, Pls. 4, 27); *Octopus longimanus, id.* (*l.c.*, p. 18); *Octopus macropus, id.* (*l.c.*, Pl. 24), delle Chiaje (1841, p. 3; 1841*a*, p. 65); *Octopus ruber,* Cantraine (1841, p. 18); *Octopus macropodus,* Philippi (1836, p. 240); *Octopus cuvieri,* Gray (1849, p. 13); *Octopus macropus,* Vérany (1851, p. 27, Pl. 10); ? *Octopus alderii, id.* (*l.c.*, p. 32, Pl. 7 bis); *Octopus macropus,* Steenstrup (1856, p. 202), Troschel (1857, p. 59), Targioni Tozzetti (1869, p. 588); *Octopus cuvieri,*

* I am indebted to Mr. C. D. Sherborn for information as to the dates on which Blainville and Risso published these works.

id. (1869A, pp. 23, 24), Tryon (1879, p. 122); *Octopus macropus*, Tiberi (1880, p. 10), Stossich (1880, p. 157), Ninni (1884, pp. 159, 161), Hoyle (1886, pp. 11, 95); *Octopus Cuvieri*, Appellöf (1886, p. 6, Pl. 6, fig. 1); *Octopus cuvieri*, Brock (1887, p. 597); *Octopus macropus*, Ortmann (1888, p. 643), Kolombatovič (1890, p. 7), Carus (1890, p. 460), Joubin (1894*a*, p. 212); *Octopus ruber*, Fra Piero (1895, p. 269); *Octopus macropus*, Lönnberg (1896, p. 706), Jatta (1896, p. 217, Pls. 6, 23, 24), (?) Goodrich (1896, p. 20), Joubin (1897*a*, p. 99), *id.* (1898, p. 22); ? *Polypus macropus*, Hoyle (1904*a*, p. 18), Hoyle (1904*b*, p. 195), Hoyle (1907*a*, p. 36 (?)); *Octopus macropus*, Marchand (1907, p. 362), Leidenfrost (1908, p. 163), Lo Bianco (1909, p. 650); *Polypus macropus*, Wülker (1910, p. 8), Berry (1912*b*, p. 389); *Octopus macropus*, Weindl (1912, p. 270); *Polypus macropus*, Wülker (1913, p. 456), Massy (1916A, p. 192); *Octopus cuvieri*, Odhner (1917, p. 70); (?) *Polypus macropus*, Sasaki (1920, p. 181), Wülker (1920, pp. 50, 56); *Octopus cuvieri*, Pallary (1920, p. 17); *Octopus macropus*, Naef (1923, p. 702), Robson (1926*b*, p. 187, fig. 16), Winckworth (1926, p. 325).

Type specimen.—(?) Municipal Museum, Nice. (? Syntypes.)

Specimens seen.

(*a*) In Brit. Mus.

One specimen (♀) from Naples: 98.5.21.344. One (♀) from "the Mediterranean": 79.1.20.2. One (♀) from Yokohama: 89.4.24.39. One (♀) from Chekiang: 1928.3.21.2. Three (♀♀♂) from Amoy: 1928.3.30.3–5. Two (♂♀) from Santuao, China: 1928.3.30.7–8. One (♂) from China (?): 84.2.21.15. One (♀) from Selangor: 1928.4.1.1. One (♀) from China: 84.2.21.16. One (♀) from the Chusan Archipelago: 92.12.14.11. One (♂), ? loc.: 97.9.28.17. One (♀), ? loc.: 68.6.8.19. Two (♀♀) from Australia: 73.5.24.1–2. One (♀) from Penang: 60.6.2.86. One (♀) from unknown locality. One (♂) from unknown locality.

(*b*) In M.H.N., Paris.

Three specimens from Mauritius. Two from Pondicherry (? type of *O. lechenaultii*). One from Teneriffe (? type of *O. longimanus*). One from unknown locality.

(*c*) In Senck. Inst., Frankfurt a/M.

One from the Red Sea. One from the Aru Islands.

(*d*) In the U.M., Leipzig.

One (♂) from Tokio.

(*e*) In U.M., Jena.

One from Messina. One from Lanzerote.

(*f*) In Z.M., Berlin.

Three (♀) from Ningpo, Japan. One from Mauritius. One from Suakim. One (♂) from the Mediterranean. Two (♀♀) from the Red Sea. One (♂) from Kobe, Japan. One (♂) from the Marshall Islands. One (♀) from Ceylon.

Distribution.—This species has been recorded from the Mediterranean (Risso, etc.), N.E. Atlantic (Joubin, Girard), the Red Sea (Wülker, etc.), E. Africa (Joubin), Persian Gulf (Massy), Indian Ocean (*ead.*, (?) Goodrich, etc.), Malaysia (Brock), Aru Islands, etc. (Wülker), Gulf of Siam (Massy), China (British Museum), Japan (Joubin, Ortmann, etc.), Australia (Odhner),

and, with less certainty, from the Marshall Islands, W. Pacific (Hoyle). There are no records from the east (unless *Octopus chromatus*, Heilprin, be a form of this species) and west coasts of America, from equatorial or South Africa, or the S. Atlantic and Southern Ocean. Having examined a good many examples from the Mediterranean, Indian Ocean and far eastern waters I am quite satisfied that the species has the wide range attributed to it by Orbigny and subsequent writers. I have had an opportunity of verifying the Australian and West Pacific insular records from specimens in the Berlin and British Museums. The variation of the species is of importance in connection with its range, and is dealt with on p. 105. The vertical range is limited to depths not exceeding 100 fathoms, though Ninni (*l.c.*) states that it has been taken from " a great depth " in the Adriatic.

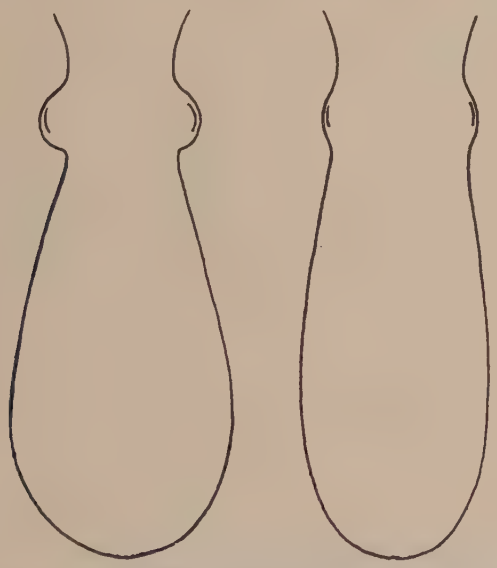


Fig. 27.—*Octopus macropus*. Outline of head and mantle in two Japanese specimens. (Z.M., Berlin.)

Description.—The mantle is usually elongate-ovoid in shape. Naef's figure (*l.c.*, p. 702) shows the form in males and females from the Mediterranean. There is some measure of sexual dimorphism, males being more slender than the females. Oriental forms tend to be narrower than European. The head is small and usually much narrower than the body. The arms are in the order 1.2.3.4., and there is little variation in this character. The first pair is usually much longer than the others, and at the same time rather thicker. The hectocotylized arm is very much shorter than its fellow of the left side. The first arms attain an average length of 84% of the total length. The diameter of the largest suckers is on an average 12% of the mantle-length, being wider in the male than in the female. The mantle-cavity is widely open (B—C). The web is highly characteristic, and the same general pattern (A.B.C.D.E.) occurs very regularly throughout all the forms examined. It is on an average 16% of the arm-length, and rarely exceeds 20%. The arm-membranes

are weakly developed. The funnel is usually very prominent and is free for about half its length. There is usually a deep infundibular notch in the locking-ridge; but the latter, though subdivided, is strong. The funnel-organ is of the *O. vulgaris* type and is usually W-shaped. There are 10–13 filaments in each demibranch. The beak of the upper mandible (Naef, *l.c.*, Pl. 18, fig. 6) is one-quarter of the total length of the mandible, and is much smaller than that of *Octopus vulgaris*. The rhachidian tooth of the radula has a marked overriding seriation of symmetrical type (A_3). In one specimen examined by me there was a distinct " lag " on one side. The first lateral has a very large ectocone with an external heel, as in *Octopus vulgaris*. The second lateral has no entocone and the " heel " is almost entirely absent. The third laterals are straight, heavy and recurved at the tip. The pallial " stylets " are rather remarkable (Jatta, *l.c.*, Pl. 24, fig. 13*b*, and Robson MS.), as they are short and very thick and unlike any which I have examined. *Reproductive organs.* The ligula

Fig. 28.—*Octopus macropus.* Penis. × 3·3.

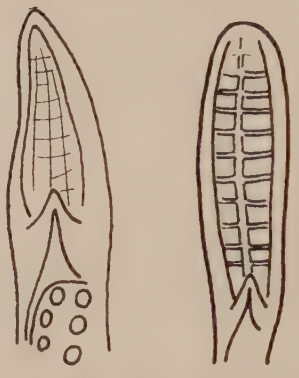


Fig. 29.—*Octopus macropus* (U.M., Leipzig). Hectocotylus. (Japanese specimens.)

of the hectocotylus as figured by Naef (*l.c.*, fig. 405) is intermediate in length between that of *O. vulgaris* and that of *O. salutii*. It is on an average 10% of the arm in length. Naef shows it as having a long rather narrow and pointed ligula with a central rib, many laminae copulatoriae and well-defined sides. This condition is found in some Oriental forms, but not all (cf. fig. 29).* The penis is figured by Marchand (*l.c.*, p. 363), and in such specimens as I have examined this organ is more or less like that illustrated in his figure, in having a thick distal extremity and large bent diverticulum. The oviduct resembles that of *Octopus vulgaris*; the distal part being 29–35% of the mantle-length, the proximal 3–10%.

The sculpture varies from close, low, rough warts to a fine shagreen of pointed granules, which probably represents the natural condition of the surface. Sometimes the latter is entirely smooth. The sculpture is in general more delicate than that of *Octopus vulgaris*. The colour of preserved specimens is mainly a dull greyish-brown or brown, and usually shows some traces of the reddish-brown of the living animal. Numbers 316–318 (British Museum) are dark purple in colour. Number 325 shows the red-splashed pattern illustrated by Orbigny (*l.c.*, Pl. 24). The species

* The ligula can also be (1) short and blunt and (2) long and "trough-like" (Berry), in which case it may exceed the arm in width (Appellöf, Z.M. Berlin).

is on the whole smaller than *Octopus vulgaris*. The largest specimen recorded (Jatta) weighed 1·6 kilograms and measured 1·5 metres over all.

Variation.—I have obtained measurements from 28 specimens from various parts of the range. The array of specimens is remarkably homogeneous. Of 28, 18 provide adequate data for the following diagnostic characters—order of arms, order of web, arms-length, web-length. The type having arms in the order 1234, web of the type ABCDE, low web (under 20) and long arms (over 82) occurs no less than 12 times; the association of long arms, web order ABCDE and arm order 1234 occurring 13 times. The frequent occurrence of the narrow head, narrow ovoid body, reddish colouring and fine granular sculpture combines with the characters already mentioned to make a very unmistakable and homogeneous group, in which no very marked geographical differentiation is obvious. As far as my material is concerned there is no difference between the Mediterranean and far eastern forms. My supply of Mediterranean forms is, however, small, and a larger supply of material might produce a different result. On the other hand, there is evidence of very considerable individual variation in certain features. In the shape of the body there seem to be two rather distinct "phases," a broadly oval one and a narrow, slender type. On the whole, the males tend to be narrower, but even among the latter there are forms with an index of over 60 and others as narrow as 32. The excessive narrowness which the mantle may show in this species is not sufficiently indicated by Naef (*l.c.*). Figure 27 shows two very narrow forms, one from the Mediterranean and one from Japan. There is also a good deal of variation in the development of the neck and the consequent distinctness of the head.

Fig. 30.—*Octopus macropus*. Female reproductive organs illustrating variation of oviduct gland.

The hectocotylus also shows some peculiar variation. In size the ligula varies from 4·8–14% of the arm. Appellöf (1886, Pl. 1, fig. 6) figures that of a Japanese specimen which is very unlike that shown by Naef. In two Japanese forms which I have seen there are marked differences in shape of ligula and calamus from that figured by Naef (see p. 104). The organ of No. C 343 is also unlike the latter. There is no gainsaying the fact that, in spite of close resemblance in other characters, Oriental forms show marked differences in the hectocotylus from the Mediterranean form. As I have so few specimens, however, and as the variation of the Mediterranean form is not known, I refrain from founding varietal distinctions on this organ, though these may ultimately be necessary. It should be pointed out that some of the eastern forms (*e.g.* those from the Marshall Islands and Aru Islands) are very typical, and resemble closely the Mediterranean form. The specimens C 150–1 (British Museum) are peculiar and not easy to determine. C 150 is a

badly preserved specimen, but it shows a mingling of *macropus* and *vulgaris* characters. C 151 is even more anomalous. It is a small male 35 mm. in mantle-length, with characteristic *macropus* ligula. The arms are in the order 4.3.2.1.; and the longest is 82% of the total length. The web is very short, 13% of the arms, and has the formula C.B.D.A.E. While having the general facies of *macropus*, it nevertheless differs from that species very markedly in some respects. It is possibly a hybrid.

Habits.—This species, which is apparently less common in the Mediterranean than *Octopus vulgaris*, lives on rocky shores (Jatta) or on both rocky and sandy bottoms (Lo Bianco, Vérany). The male is taken with ripe spermatophores in April and May (Lo Bianco). There are no observations on its habits, food, etc.

Maximum size.—1·5 m. (Jatta).

Remarks.—Although this species has been repeatedly recorded and described under the name of *Octopus cuvieri*, there is no justification for the use of that name. The plates illustrating this form, and bearing the names *Octopus cuvieri* and *leschenaultii*, were completed and issued by Orbigny in 1826, shortly before Risso's publication of the description of "*Octopus macropus*." I do not think, however, that there is any evidence of the publication (in the strict sense) of these plates, so that Risso's name has a clear priority. Its reddish colour, the order of the arms and web-proportions render the species easily recognizable from its allies in the Mediterranean and elsewhere. *Octopus granosus*, de Blainville, from Sicily ("finement granulé en dessus comme en dessous, appendices . . . huit fois aussi longs que le corps . . . allant graduellement en décroissant depuis la première paire inférieure jusqu'à la quatrième supérieure . . . brun rougeâtre en dessus") may be included here, and also may have a title to priority. It is, however, described as having a globular body, the order of the arms is not that of *O. macropus*, and the web is "assez peu palmé." * *Octopus alderii*, Vérany, is considered by Naef (*l.c.*, pp. 706–7) to be a young form of *Octopus macropus*, and I think his opinion should be received with consideration, especially as he evidently took care to examine a series of young forms of unmistakable *macropus*. He points out that in young *macropus* the arms are little differentiated in length, which is a feature of *alderii*. He does not, however, note the following facts. (*a*) In Vérany's type the longest arms are only about $1\frac{1}{2}$ times as long as the mantle and head, while in his own figure of a young *macropus* (fig. 419 and p. 706) they are about 3 times as long. (*b*) In Vérany's description the arms are in the order 2.1.3.4.; whereas, according to Naef, the characteristic arm-formula of *macropus* (1234) is in the young "bereits leicht feststellbar." I do not think that we should attach overmuch importance to (*b*). Vérany (p. 32) describes his species as smooth. The adult *macropus* is, of course, sculptured. Naef does not discuss whether the young "*alderii*"-like *macropus* is smooth or sculptured. On the whole, I think it is necessary to pursue the study of the young stages of the Mediterranean species more fully before we can decide to which of the latter we should assign this form. It is interesting to note that Jatta (*l.c.*, p. 299) states that his only specimen was pelagic (see Introduction, p. 23).

The relation of *O. macropus* to *Macroctopus maorum* is discussed on p. 175.

* The figure alluded to by Blainville (1828, p. 7) was apparently never published.

Octopus (Octopus) macropus var. **minor,** Sasaki.

Polypus macropus var. *minor*, Sasaki (1920, p. 181).

Holotype.—In U.S.N.M., Washington.

Distribution.—Suruga Bay, Japan, in 47 fathoms.

Description.—This interesting form has an " elongate fusiform body, somewhat pointed behind "; the head is about as wide as the body. The funnel-organ consists of two " far-separated V-shaped pads, of which the inner limb is $\frac{1}{2}$–$\frac{3}{5}$ as long as the outer." The hectocotylus is about 14% of the third arm and spoon-shaped. There are only 7–8 filaments in each demibranch, a low number for the species.

Remarks.—The funnel-organ is very remarkable and unlike that of any species hitherto described in the subfamily. The species may have been incorrectly determined. I have never seen a similar funnel-organ in the slender Oriental forms of *O. macropus* which I have examined.

Octopus (Octopus) chromatus, Heilprin.

Octopus chromatus, Heilprin (1888, p. 324, Pl. XVI, fig. 1).

Holotype.—Mus. Academy Nat. Sci. Philadelphia.

Distribution.—Only known from the Bermuda Is. (" Flatts Village "). A single specimen was taken beneath a stone on the beach.

Description.—The body is " spheroidal, somewhat acuminate behind." The head is rather wide and not much narrower than the body. The eyes are inconspicuous. The arms are in the order 1.3.2.4. (? 1.2.3.4.), and are very slender and tapering. The exact measurements are not given, but the longest arm seems to be 86–85% of the total length. The suckers are " fairly large " and " contract with a quadrangular outline." The form of the web is not described, and cannot be guessed from the figure. It would seem to be under one-fifth of the arm-length. The funnel is " largely free, reaching about half-way to the base of the web." The surface is " granulated posteriorly and to a less degree in the region of the neck." Over each eye there is a wart. The colour is " milky, closely blotched or speckled with ochre . . . and sprinkled with brown."

Maximum size.—The only known specimen was 9–10 inches long.

Remarks.—The extreme length and attenuation of the arms suggest that this form may be referable to *O. filosus*, but the bodily shape, order of the arms and sculpture do not resemble those of Howell's species. *Octopus rugosus* can hardly be considered, on account of (*a*) the length and order of the arms and (*b*) the colour of *O. chromatus*, though the sculpture and size of the web are suggestive. The outline of the visceral sac is also not unlike that of *O. rugosus*. Heilprin compares his species with the very young *O. bermudensis* of Hoyle (1886), an identification which is possibly correct; but, in view of the fact that Hoyle's specimen was very small, it is desirable to await more evidence. I am inclined to suspect that it may be a form of *macropus*, though the head is wider and the body more compact than in that species.

Octopus (Octopus) taprobanensis, Robson.

(Plate VI, fig. 2.)

Octopus taprobanensis, Robson (1926, p. 165, fig. 7); *Octopus* sp. Winckworth (1926, p. 328).

Holotype.—In Brit. Mus.

Specimen seen.—One specimen (Type) (? ♀) from Pearl Banks, Periya Paar, Ceylon: 1925.11.23.2.

Distribution.—Periya Paar, Ceylon (only known from the type locality).

Description.—This curious (though undoubtedly juvenile) form has a markedly pyriform body with a pointed apex. The head is very narrow, and there is a distinct infraocular constriction. The arms are, as usual, short and the suckers minute. The oral suckers are arranged in a well-developed peribuccal ring. The arms are in the order 1.2.3.4., and the first arms are almost twice as long as the fourth. The web is very low (as in many young forms) and subequal. The funnel-organ is W-shaped and there are ten filaments in each demibranch. The surface is entirely smooth, and is buff in colour with a number of large purple chromatophores arranged more or less quincuncially.

Total length.—61 mm.

Remarks.—The status of this species has already been discussed (Robson, 1926, p. 167). It was shown there that there is a superficial resemblance to *O. alderii* (= *macropus* juv. *fide* Naef); but the differences between these two forms are pronounced. The type of *O. alderi* (Vérany, 1851, p. 32) was 28 mm. long, and the arms were in the order 2.1.3.4., with a difference of 9 mm. between the longest and shortest. In Jatta's example (1896, p. 230) the size of the mantle was 15 mm. The arms were in the same order, and the size difference was 7·5 mm. In *taprobanensis* (type 20 mm.) the order is 1.2.3.4., and the size difference is 21 mm. In short, our specimen, though smaller than the type of *O. alderi* and only a little larger than Jatta's specimen, is much more like *macropus* in its arm-size and ratio. On the other hand, the web shows no signs of attaining the form peculiar to *macropus*, and, although the body is elongate and the head very narrow, its shape (Pl. VI, f. 2) is so peculiar that it is difficult to imagine it growing into the typical *macropus*, especially as Naef (Fig. 419, p. 706) shows that the "*alderi*" state of *macropus* has very largely attained the definitive adult shape. Concerning this ambiguous form little can be said until the problem of growth and form-change in the Octopoda is thoroughly understood. It is certainly not unlike a young form of *macropus*; but, as the mantle-shape is so distinctive, I think it undesirable to treat it as synonymous with that species.

Habits.—Winckworth (*l.c.*, p. 238) states that it was taken "in a tow net at surface, lit by electric light."

Octopus (Octopus) ornatus, Gould.

Octopus ornatus, Gould (1852, p. 476, fig. 590, 590*a*); *Polypus ornatus*, Berry (1909, p. 418), *id.* (1914*a*, p. 294, Pl. XLVI).

Syntypes.—? In U.S.N.M., Washington.

Distribution.—The Sandwich Is. (Oahu and Maui (Gould); Honolulu Reef (Oahu) (Berry)). See also Berry (1914*b*, p. 139).

Description.—The body is subglobose and is broadest at or behind the middle line. The mantle-aperture is moderately wide (? type B). The head is very much narrower than the body, and is separated from it by a moderate (Berry "decided" (but cf. his figure (Pl. XLVI)) "neck." The eyes are fairly prominent. The arms are in the order 1.2.3.4. (Berry) or 2.4.3. = 1. (Gould), and are very long (90–85% of the total length). The largest suckers are 12–13% of the mantle-length. They are "very numerous and crowded" (Berry). The web is not described in detail by Gould or Berry. According to the figure given by the former the formula would be B.A.C.D.E. According to Berry A. is the largest and E. the shallowest. As a whole it is very shallow and attains a maximum depth of 10–11% of the arms. The funnel is long and reaches to about two-thirds of the way from the mantle-aperture to the edge of the web. It is free for half its length, and has a W-shaped organ. The hectocotylized arm is a third shorter than its fellow. The terminal organ is, at the most, 3·8% of the arm in length. The ligula is elongate-conical, its surface is "broadly, but not abruptly excavated" (Berry), and exhibits 9–10 close ridges (? wrinkles or laminae copulatoriae). The surface is nearly smooth below and coarsely and irregularly papillose above, the papillae being generally arranged in longitudinal lines, in some areas forming marked ridges. There are three supraocular cirrhi.

Colour: "deep orange variegated with longitudinal buff stripes" and deep brown patches (Gould). In alcohol, dull buff clouded with reddish chocolate (Berry). The longitudinal ridges are enclosed in a band of buff, and a conspicuous series of reticulations is found in pairs along the outer surfaces of the four dorsal arms.

Maximum size.—650 + mm. (Berry). Gould's specimen was evidently larger (perhaps 665 mm.), but his measurements are not given in such a way as to provide the total length.

Remarks.—Both Gould and Berry comment on the resemblance of this species to *O. macropus*, and from the latter's account (1914, p. 296) it would appear that the two species "are throughout essentially similar in structure" and of a "very close degree of relationship." Berry thinks that *O. macropus* is the parent form, and that *O. ornatus* has diverged from it principally in colour-pattern and sculpture owing to its localized habitat. If this were true, it would be a very interesting fact, illustrating localization and race-formation in a group not prone to this tendency. But with deference to Dr. Berry's knowledge and his inspection of specimens which I have not seen, I think the close relationship with *macropus* is exaggerated. Not only are the colour and sculpture very distinctive, but also the hectocotylus is markedly different. I admit that *macropus* is very polymorphic, but I have never seen in undoubted examples of that species a terminal organ such as Berry figures (Pl. XLVI, fig. 2). It is a pity that the organ figured is not fully developed (Berry, *l.c.*, p. 360). Again, the order of the arms of the type specimen does not agree with that found regularly in *O. macropus*. Finally, Berry describes the web as having A the largest sector, whereas in Gould's figure B is larger than A on one side and equal to it on the other. Finally, it must be noted that Berry's three male specimens have a width index of 83, 100 and 104 respectively, and are thus globular forms, whereas

in *macropus* the male is usually slender. In short, I think that, though the two species are obviously allied, the relationship is not so close as Dr. Berry thinks.

Octopus (Octopus) medoria, Gray.

(Plate IV, fig. 2.)

Octopus medoria, Gray (1849, p. 14), Tryon (1879, p. 123), Hoyle (1888, p. 221, as " insufficiently characterized ").

Holotype.—In Brit. Mus.

Specimen seen.—In Brit. Mus.

One ♀ from unknown locality (Type) : 1927.2.13.1 (old collection).

Distribution.—Unknown.

Description.—The only available specimen is in rather poor condition. It measures 29 mm. in mantle-length. The mantle is short and conical, wider anteriorly and rather acuminate apically. The head is rather large and not much narrower than the mantle. One eye is very much distorted; but these organs would seem to have been large and prominent. A well-marked " neck " separates head and mantle. The arms are in the order 1.2.3. = 4., 1.2.3.4., and are rather long (84%). The suckers, though very prominent, do not exceed 10% of the mantle-length. The web is damaged, but its sections would appear to have been subequal and rather low (16%). E is a little shorter than the rest. There are scarcely any arm-membranes. The funnel is free for just under half its length. The funnel-organ is rather peculiar, as the outer limbs are rather less than half the length of the inner. There are 12 filaments in each demibranch and the distal filaments are very much reduced. The radula has a rhachidian with remarkably long mesocone, the ratio of the length of which to the breadth of the base is 93 : 58. This tooth has an A_4 seriation. The admedian is narrow, and has a very prominent cusp. The second lateral has a very angular base, a heel, but no entocone. The third laterals are short and very much recurved. The web and body are finely granular, some of the granules being larger than the others.

The preserved animal is very much discoloured. It is dirty brown in general hue, with obscure patches of dark purplish-brown, which seem to be more or less associated with the larger granules.

Remarks.—Tryon (*l.c.*) suggests that this species is very likely the same as *O. cuvieri* (= *O. macropus*). There are, in fact, certain points of resemblance; but *medoria* differs from *macropus* in (1) the moderate size of the first arms, (2) the subequal sections of its web, (3) the shape and size of the head, and (4) the form of the funnel-organ. I think it is allied to *O. macropus*, but probably not conspecific.

Octopus (Octopus) machikii, Brock.

Octopus machikii, Brock (1887, p. 599).

Holotype.—In the University Museum, Göttingen.

Distribution.—Amboina (only known from the type-locality).

Description.—The species is only known from a single female specimen. The mantle is evidently elongate-ovoid and rather pointed posteriorly.

The eyes are large and prominent. The arms are in the order 1.3.2.4. (3 = 2 ?), and the first pair is 77% of the total length. There is apparent no enlargement of the suckers. The web is poorly developed, A being deeper than E. These are the only sections of which the depth is given. E is 14% of the longest arms. The web is continued up the arms as lateral membranes. The funnel is large and pointed. The skin is finely granular below, more coarsely granular above. It is clearly and finely wrinkled on the dorsum, head and on the dorsal surface of the web. The ground-colour is a dark ochreous yellow closely covered (especially dorsally) with brown, violet or black chromatophores. Brock says the colour of this species is very like that of *Philonexis carena* (= *Ocythoe tuberculata*). He also states that it is strikingly similar to his own *O. amboinensis*, but that he regards it as distinct on account of (1) the order of the arms, (2) the structure and arrangement of the suckers. With regard to the value of (1) we may express some doubt. As to (2), Brock points out that the more slender and compressed arms and more widely spaced suckers of *O. amboinensis* recall those of *Philonexis* (= *Ocythoe*), while the more ovoid section of the arms and more closely serried suckers of *O. machikii* are more typically *Octopus*-like. I should have thought that (3) the sculpture and, in a less degree, (4) the coloration were also distinctive.

Maximum length.—90 mm.

Remarks.—This is represented by a single young specimen, the mantle-length of which is about 20 mm. in length. It is quite impossible to say if it is the young of any described species, though I am provisionally inclined to think that it is nearly related to *O. macropus*.

b. Sub-group of **Octopus leioderma** (see p. 35).

Octopus (Octopus) leioderma (Berry).

Polypus leioderma, Berry (1911, p. 590), (1912*a*, p. 288, Pl. XXXV, fig. 1; Pl. XL, figs. 4–5).

Holotype.—In U.S.N.M., Washington.

Distribution.—Monterey (California) to Shelikoff Straits (Alaska) in 106–239 fathoms.

Description.—The body is short, plump and surrounded by a narrow but distinct lateral keel. Berry's measurements do not include the apex-eye measurement, but from his figures it is possible to calculate the width-indices, that of the mantle being about 100, that of the head 77. It is one of the squattest and plumpest species known.* The profile is rather like that of *Benthoctopus berryi* (Robson, 1924). The arms are in the order 1.2.3.4., unequal and with an index of 70–71. The mantle-aperture seems to be narrow (B). The suckers are small and nowhere specially enlarged. The web seems to be in the order A = B = C > D > E, and to be about 25% of the arm's length. The arm-membranes are broad and well-developed. The funnel is long and rather slender. The funnel-organ is not described. The hectocotylus is unknown. " The surface is smooth except for a number of short, rather obscure simple papillae " on the dorsal surface of the head, neck and mantle. There is a single tubercle

* There is some discrepancy between the dimensions as shown in the measurements and those seen in the figure (Pl. XL, fig. 4).

over each eye, and the rest are bilaterally arranged, " the most notable being a nearly equidistant row between the eyes." The colour is very pale-grey buff suffused with purplish-brown.

Maximum length.—210 mm.

Habits.—This species is evidently an inhabitant of rather deep water, as all the specimens are from 106–239 fathoms.

Remarks.—I am a little uncertain as to the status of this species. Berry says that probably none of the specimens available is quite mature. His reliance on the lateral keel as a striking difference between it and its congeners is not quite justified (cf. p. 7). The shape, the shortness of the arms (? due to age) and form of the web are perhaps distinctive in combination. It is hoped that Dr. Berry will publish an account of the funnel-organ, radula, etc.

It is possible that this species may be referable to the Bathypolypodinae. The narrow mantle-aperture and short arms, in conjunction with the rather deep-water habitat, suggest this relationship.

Octopus (Octopus) longispadiceus (Sasaki).

Polypus longispadiceus, Sasaki (1917, p. 366; 1920, p. 178).

Holotype.—In Science College, Tokyo.

Specimen seen.—One (♂) from " between Matsu Shima and Nagasaki," U.S.N.M. 332984 (recorded by Sasaki as from Cape Clonard, Korea).

Distribution.—Korea, Hyuga-Nada and Rikuzen (Japan) in 150–437 fathoms. It is reported by Sasaki (1920) on p. 178 as from Stations 4867 and 4957, with the depths above given; but in the list of stations (pp. 165–166) it is not given among the species taken at those stations!

Description.—The breadth of the mantle is 81–100% of its length, and in one specimen (Korea) there is a peripheral keel not found in the others. The head is broad (73–94% of the mantle-length). The arms are mostly in the order 1.2.3. = 4. They are 78% (Korea), 81% (Hyuga Nada) and 83–84% (Rikuzen) of the total length. The suckers at and beyond the mantle-margin are conspicuously enlarged and attain a maximum size of 24%. Those of the fourth arm are not enlarged. The web in the Matsu Shima and Hyuga-Nada specimens is broadest between the dorsal arms, and in those from Rikuzen attains a depth of 20–25% of the arms. The surface of the body, head and arm-bases is covered with single, roundish warts, most frequent and best developed above the eyes. A single wart over each eye is enlarged. The colour is not described.

The gills have 10–11½ filaments in each demibranch. The funnel-organ is " thickly W-shaped." The first part of the ink sac is buried in the liver. The hectocotylized arm is about the same length as its fellow (slightly shorter in the Hyuga-Nada specimen). The ligula is slender and about 9–10% of the arm in length and resembles that of *O. hongkongensis*, Hoyle. The penis appears to have a long diverticle. In the Hyuga-Nada specimen the form of the spermatophoric glands differs from that seen in the type specimen.

Remarks.—This species seems to form a link between *Octopus* and *Paroctopus*, as it resembles *P. hongkongensis* in certain respects. The specimens obtained off the coast of Korea and off Hyuga-Nada are

" referred with great doubt " to this species. Their distinctive features are described above; but it does not seem likely that they should be referred to a different species. As in *P. yendoi* the presence of a long diverticle to the penis recalls the similar structure of *Enteroctopus*. The general facies, however, inclines one to retain the species in *Octopus*.

Octopus (Octopus) tsugarensis (Sasaki).*

Polypus tsugarensis, Sasaki (1920, p. 175, Pl. 23, fig. 4).

Holotype.—In U.S.N.M., Washington.

Distribution.—Tsugaru Strait, Japan, in 195 fathoms.

Description.—The mantle is broader than long and is expanded posteriorly. The head is a little narrower than the body and there is a weak " neck." The mantle-aperture is moderate (? B). The arms are subequal and about 80% of the total length. Two pairs of suckers are enlarged on the dorsal arms. The web is said to be " well developed." Sasaki states that it extends up the lateral arms for more than a quarter of their length (25%+), and that it is especially well developed between the dorsal and second arms (formula ?B = A. C = D.E). The surface is smooth except for some " faint " warts about the eyes and flat ocular cirrhi. The colour (preserved specimen) is reddish-brown with three obscure transverse stripes of a darker shade on the head. The funnel is rather long and the funnel-organ very characteristic, recalling that of *Paroctopus apollyon*, though the lobes are all triangular and sharply pointed distally. The gills have 9½ filaments in each demibranch. The hectocotylized arm is only a little shorter than its fellow. The ligula is 9% of the arm, is furnished with laminae copulatoriae and has a well-defined groove. The penis is slender and bent crescentwise (? naturally), and the duct of Needham's organ enters it in advance of the middle (? long appendix). Needham's organ is slender and bent in the shape of an L.

Maximum size.—145 mm.

Remarks.—From the size of the ligula, this may be referable to *Paroctopus;* it is only placed here provisionally.

C. Group of **Octopus aegina.**

c^1. Sub-group of **Octopus aegina.**

Octopus (Octopus) aegina, Gray.

(Plate V, fig. 1; text-figs. 31–32.)

Octopus Ægina, Gray (1849, p. 7); *Octopus kagoshimensis*, Ortmann (1888, p. 644, Pl. XXI, fig. 2*a*, *b*); *Octopus Ægina*, Hoyle (1889, p. 221, as " insufficiently characterized "); *Octopus rugosus* [? pars = *kagoshimensis*], Ortmann (1891, p. 669), Massy (1916A, p. 189); *Polypus granulatus* (? = *kagoshimensis*), Wülker (1910, p. 6); *Octopus aegina*, Robson (1928*a*, p. 641, figs. 1–4).

Holotype.—In Brit. Mus.

* This species is placed here as it seems to have a general resemblance to the *leioderma* group. It has, however, few *macropus*-like traits and is probably a link between the *leioderma* group and *Paroctopus* (cf. p. 35) standing nearer to the latter than *O. longispadiceus*.

Specimens seen.

(*a*) In Brit. Mus.

One (♀) from unknown locality (Type) : 1928.2.14.1 (old collection). One (♂) from Amoy (Ping) : 1928.3.30.6. One (♀) from Siam : 1928.3.16.1. One (♀) from Kurrachi : 83.8.17.68. One (♂) from China : 52.1.1.4.

(*b*) In Mus. Zoologique, Strasbourg.

Seven (4 ♂, 3 ♀) from Japan (Ortmann), types of "*O. kagoshimensis*."

Distribution.—China, Amoy, Siam, Kurrachi (Brit. Mus.); Kagoshima, Japan (Ortmann).

Description.—The mantle is usually elongate-ovoid with a width of 40–58% of the length (the Siamese specimen is broader). The head is narrower than the body (31–42%), and is well defined. The arms are in the order 3.4 = 2.1., 4.3.2.1., or 2.4.3.1., and are from 71–77% of the total length. The suckers are small, about 9% of the mantle-length, and are not specially enlarged in the male. The gills have 7–9 filaments a side. The web has the formula D.C.E.B.A. or D.E.C.B.A., and attains a depth of 30–22% of the arms. In extreme cases it exhibits the curious shovel-like form figured by me (Robson, 1928*a*, fig. 3), but this is a little unusual. Sector A is always at least half as long as C and D, but in the type specimen it is nearly a third as long. The mantle-aperture is moderate (B). The funnel is free for about half its length, and the funnel-organ is **W**-shaped and well developed, with thick limbs. The hectocotylus has a terminal organ about 8–5% of the arms in length. That of the specimen from Amoy (1928.3.30.6.) agrees quite closely with Ortmann's type of *kagoshimensis*. The ligula is long, pointed and narrow. It is faintly striated and has a small, but well-developed calamus.

Fig. 31.—*Octopus aegina*. Hectocotylus. ("Kagoshimensis," Ortmann.)

The rhachidian tooth has an A_2 seriation. The first lateral is very long. The second lateral has no ectocone, but a well-developed heel. The structure of the penis and its accessory organ is very remarkable, and like that of no other Octopod which I have seen. From Fig. 32 it will be seen that it consists of (A) the penis proper with a short rounded appendix, (B) a second penial appendix, which is twice as long as the penis and is continued into (C) a third appendix, which is long and narrow and nearly five times as long as the penis. The duct joining the penis and Needham's organ is very long and slender. This remarkable ensemble is found in all four adult males in the type series of *kagoshimensis*. On first examining it I was under the impression that it was simply due to the presence of spermatophores in the appendix, those bodies often producing some measure of distortion in the penis itself. But I am now convinced that this is not the case and that the male copulatory

Fig. 32.—*Octopus aegina*. Penis and diverticulum. × 2.

apparatus of *O. aegina* is unique, for the following reasons :—(1) The system is identical in all four males, (2) in no forms with long spermatophores have I ever seen this degree of distortion, and (3) the parts of the system are very clearly differentiated and in a similar fashion in all the specimens. The oviduct is of an unusual type, the vaginal part being differentiated into two distinct regions. The proximal moiety is very short.

The sculpture consists, when well developed, of closely applied polygonal warts forming a coarse encrusted surface. In the less well-developed condition the warts become flat, broadish scales. The coarse encrusted texture of the surface is particularly well seen on the arms in two of our specimens. In my paper on this form (1928*a*) I stated that Gray's type is smooth. On re-examining it I find traces of obscure sculpture. The colour seems to be a pale purple or vinous red, with a very neat purple reticulation on the head and arms. In the type and one or two others this pattern is very elegant, especially on the web and dorsal side of the arms. Specimen 52.1.1.4. is devoid of this reticulation, and in Ortmann's types it is very obscure.

Remarks.—I consider that this species differs from *O. rugosus* in the following respects :—(1) The sculpture is coarser and composed of heavy polygonal warts, not of granules or multifid warts. (2) The body and head are much narrower. (3) The web, though of the same general type and having A very deeply incised, differs regularly in that A is *always* nearly half as deep as D, a condition I have found only once in *rugosus*. (4) In the male reproductive organs (*a*) the ligula is much narrower and (*b*) the penis and its appendices are totally different.*

The identification of the much discussed *O. kagoshimensis* with this species is satisfactorily established by a comparison of the types.

It might be considered desirable to place this form in a separate genus or subgenus on account of the remarkable structure of the diverticle. The species is, however, in all other respects a normal member of *Octopus*, and until more is known as to the frequency with which the singular diverticle occurs it seems better to avoid creating a new genus or subgenus.

Octopus (Octopus) hardwickei, Gray.

(Plate III, fig. 2.)

Octopus Hardwickei, Gray, 1849 (p. 8; cites "Gray, Brit. Mus., 1826"), Hoyle (1888, p. 221 as "insufficiently characterized").

Syntypes.—In Brit. Mus.

Specimens examined.—Two specimens (♂ ♀) from the Indian Ocean : 1927.12.10.1–2. (old collection).

Distribution.—Known only from type locality, Indian Ocean (? Singapore).

Description.—The mantle is narrow and oblong in both specimens. The arms are not easy to measure accurately on account of the extreme delicacy of the tips. They seem to have the formula 4=3. 2=1. or 4.2.3.1., and are rather short, viz. 70–75% of the total length. In both specimens a varying amount of the extremities is very slender and drawn to a fine, filiform termination. About half-way down the arms the suckers decrease in width, and from that point they become more and

* *Octopus dollfusi*, Robson (1928, p. 43) may be related. The paper in which this species was described was received in England after this section was printed.

more obscure until they disappear at a point at the following distances from the arm-tips :—1st arm, 10 mm.; 2nd arm, 12 mm.; 3rd arm, 21 mm.; 4th arm, 17 mm.

The pallial cavity is rather widely open (B–C) and the branchial lamellae number about 8 aside. The suckers are not noticeably enlarged in either sex, the largest of the male specimens being 7–8% of the mantle-length in diameter. The web is moderate in extent (25% of the arms), but it lacks the well-developed membranes extending up the arms which are usually found in this group. It has the form C.E. = D.B.A. The funnel-organ is not preserved. In the radula the rhachidian has the formula A 5–6 : the first lateral is long and has a high cusp. The second lateral is devoid of an entocone. The marginals are well developed. No trace of a ligula copulatoria was found on any of the arms. The third arm has a well-defined spermatic groove which extends about half-way up the arm, at which point it disappears. The penis is about 18% of the mantle in length. It has a capacious diverticulum, set at right angles to the long axis of the penis, a very unusual arrangement. The visceral sac is smooth except in the anterior mid-dorsal line, where there is a tract of low single warts which expands laterally over the head and on the web. There is a fine reticulate dark colour-pattern, seen at its best on the head and web. Both sculpture and colour are better developed in the male specimen.

Remarks.—This very distinctive form has not been redescribed or recorded since 1849. The original account is very defective. The species seems to have affinities with *O. aegina* in the structure of its arms and in its general build, though I think it must be regarded as distinct. An unknown hand (possibly Steenstrup's) has written in the annotated copy of Gray's Catalogue "*Aegina verant*" (? verändert). It differs from *aegina* in (1) the length of the arms, (2) the character of the sculpture, and (3) the form of the web.

c[11]. Sub-group of **Octopus areolatus.**

For a long time students of the Octopoda have been familiar with a group of small Oriental species distinguished by the presence of a dark ocellus containing an iridescent ring. The most common names applied to them are *ocellatus*, Gray, and *areolatus* (de Haan MS.), Orbigny. They have been frequently recorded under these or other names; but the identity of the component species and the use of the names that are to be given to them have invariably been misunderstood.

(1) In 1840 (*l.c.*, p. 68 and Pl. 9) Orbigny figured (copying a Chinese drawing) and described (quoting the Japanese Encyclopedia) an *Octopus sinensis*. The most striking features of the animal figured are a large pigment spot surrounded by a light annulus situated between the eye and the edge of the web, and a light brown patch placed between the eyes. Inasmuch as the species figured is a common Japanese and Chinese form, and the two species here discussed are likewise the most common forms with ocellus and interocular patch in Chinese waters, the question arises, Can Orbigny's name be used for one or the other? I think that the description and figure do not enable us to decide this question. The ocellus in the Chinese drawing is not strictly like that of either *ocellatus* or *areolatus*, as it lacks the external dark annulus and the description is

very deficient. Orbigny's name, although it was actually placed (as *ocellatus* in error) in the synonymy of his *ocellatus* by Gray, cannot be considered in this context (see p. 124).

(2) In the same work Orbigny (*l.c.*, p. 65) gives a very slight and wholly unserviceable description of *Octopus areolatus*. He had seen no specimens of this species, and the name and description are derived from a letter of de Haan, so that the name stands, for what it is worth, to Orbigny's credit. Fortunately the syntypes (the specimens used by de Haan in drawing up his MS. description) were traced to the 's Rijks Museum, Leiden, where they were seen by Appellöf and lately (through the kindness of Dr. C. Blöte) by myself. The first full and adequate description of *areolatus* is that of Hoyle (1886). It is based on the single "Challenger" specimen, which Hoyle diagnosed as referable to the de Haan–Orbigny species on the strength of a comparison with two specimens in the Copenhagen Museum which Steenstrup had named after comparison "with some [presumably the types] labelled *Octopus areolatus*, de Haan, in the Leyden Museum." The right of the "Challenger" specimen to bear this name is thus secondhand. A close study of the two syntypes in the Leyden Museum convinces me that they are referable to two distinct species. One of these agrees fairly closely with the "Challenger" *areolatus*, the other I think is undoubtedly referable to Gray's *ocellatus*. We are thus confronted with a happily rare kind of nomenclatorial difficulty. The de Haan–Orbigny *areolatus* has for its types two distinct forms, and the question arises, Which of the two is the real type of *areolatus*? Inasmuch as Orbigny's description is useless, I think the solution is—that the form described by Hoyle as *areolatus* should retain that name, and of the two Leyden specimens the one most like Hoyle's *areolatus* is to be reserved as the type of that species. The other undoubtedly is referable to Gray's *ocellatus*.

It is perhaps worth while pointing out that Orbigny's description is as follows:—"toute la surface du dos aréolée, avec une tache obscure dans chaque aréole, *de la forme de l'Octopus Lechenaultii*." The italicized passage is obscure. It may refer to the "taches," or it may be a general description of the whole animal. Actually, though the *areolatus* of Hoyle and the Leyden example have a long narrow body, as in some examples of *O. macropus* (= *lechenaultii*), they are otherwise very different from the latter. It therefore follows that Orbigny's description is not only inadequate, but also misleading. It is arguable that, as Orbigny's description contains matter not applicable to Hoyle's "*areolatus*," the latter should not bear that name. In this case I think we are right in being guided by the type to which Orbigny's name is obviously applicable.

(3) In 1849 Gray gave a short description of *Octopus ocellatus*, of which the type is still available, and resembles, as we have seen, one of the "*areolatus*" types. In 1886 Appellöf published a fuller description of this species, using a Chinese specimen by no means like the type and indeed resembling *areolatus* in some respects. Since that time various authors (*e.g.* Massy, 1916A; Berry, 1912*b*) have identified this species with *areolatus* or surmised that the two forms might be identical. The following are the most important features of (*a*) de Haan's two specimens, (*b*) the type of *ocellatus*, Gray, and of (*c*) Hoyle's *areolatus*.

	"*Areolatus*" Orb. (de Haan (MS.). (Leiden.)		*Ocellatus* Gray. ♂.	*Areolatus* Hoyle (corrected). ♀.
	No. 1 ♀.	No. 2 ♂.		
1. Width-index .	88	43	93	63
2. Mantle-shape .	Broad and globular	Long and narrowly ovoid	Squat bursiform	Oblong and narrow
3. Head-width .	55	32	60	52
4. Arms, formula	3.2.4 = 1.?	3.4 = 2.1.	3 = 4.2.1.	3.2.1.4.
5. Arms % length	81	78	81	68
6. Web % arms .	27	26	21	31
7. Web disparity	33	38	29	19
8. Ocellus length % mantle .	—	—	35	14
9. Sculpture .	Close compact masses of little warts, sometimes fused	More or less like 1 but more worn	Large multifid warts	Fine close single warts
10. Gills . .	—	—	7/8	10/12

From the figures it will be seen that Orbigny's *areolatus* is quite definitely composed of two very distinct forms, and that Gray's *ocellatus* resembles "Orbigny 1" and Hoyle's *areolatus* is like "Orbigny 2." The crucial characters are the width and shape of the mantle, the width of the head and length of the arms. Gray's type specimen and that of Hoyle differ also in respect of two more characters for which de Haan's types were not examined (length of the *ocellus* and gills). It should be noted that "Orbigny 2" and the type of *ocellatus* are both males of nearly the same size. The differences between them cannot be therefore due to age or sex. Since these forms were first described a number of additional specimens have been described and assigned to one or the other species. On analysing the available figures I find that a certain number agree fairly closely with one or the other type forms, and a few are definitely intermediate. The number of individuals resembling one or another quite distinctly is sufficiently high to justify the recognition of two species, at least for the present. The intermediates are, however, quite striking. If they are due to crossing, it is very remarkable that two such dissimilar forms should interbreed. How unlike the extremes are will be best realized by studying Plate VII. One other curious fact must be pointed out—the striking *ocellus* with lustrous inner annulus and the brown reniform head patch are present in a certain number of individuals of each species.

The following is a brief summary of the identity of the types.

"Orbigny 1": narrow, short-armed form (♂) is the type of *areolatus*, Orbigny.

"Orbigny 2": broad, long-armed form (♀) resembles type of *ocellatus*, Gray.

Variation.—On p. 119 is given a special table of measurements of specimens of the two species. From this it will be seen that the variation of the two species is very considerable, and that many characters are

TABLE OF MEASUREMENTS OF *OCTOPUS AREOLATUS* AND *OCTOPUS OCELLATUS*.

	Mantle width.	Inter-ocular width.	Order of arms.	Longest arm, % total length.	Web.	Web, % longest arms.	Hect., % arm.	Sculpture.	Eye spot, position and % mantle-length.
A. Referred to in this work as *Octopus areolatus*.									
1. Hoyle (1886)	63	52	3214	68	18 22 24 25 22 C = D., B = E.A.	31	—	Simple close warts.	Nearer eye; 14% m.l.
2. Brock (1887) (? from Hoyle)	—	—	Subequal } 4<rest }	sc. 66	—	Very long	—	Shagreened with close fine warts	—
3. Massy (1916A)	76	52	3421 } 423 = 1 }	70	—	33	13	Closely set with round tubercles	Midway between eye and web
4. Appellöf (1886)	51	33	4321	75–76(?)	{ Well developed { ? C = D = E.B.A.	? 20	?	Covered with small close set warts	Nearer eye; 17%
5. Ortmann (1888) as *O. brocki*	? 60	? 33	—	69	BCDEA	25–33	4·4*	Smooth mainly, neck and head weakly granular	—
6. Type (R.M., Leiden)	43	32	3.4 = 2.1	78	C = D, B = E.A.	26	7·0	Close compact masses of small warts	?
7. Mus.Ac.N.S., Philadelphia	56–62	35–38	—	75–74	CD.EBA	32	6·0	Rather coarse warts, occasionally multifid	24–17% : nearer eye
B. Referred to as *Octopus ocellatus*.									
1. Gray (1849) (Type)	93	60	3 = 4.21 4312	81	C = D = E.B.A.	21	6·1	Coarse round multifid warts	Nearer eye: 35%
2. Berry (1912) i.	83	50	?	69	—	—	5·7	Heavily papillose with stellate or polygonal warts	? 28%
(?) ii.	94	69	?	77	—	—	—	Smooth	? 26%
3. R.M., Leiden	88	55	3.2.4.–1 ?	81	C.D.B.E.A.	27	—	Close compact masses of small warts	—

Joubin's data (1894) not included as the " body length " is only given " to root of arms."

* From type specimen (the magnification of Ortmann's figure is incorrectly given).

shared in common. No forms are more distinct than the extreme *areolatus* and *ocellatus*, and in some of the specimens studied the characters of the extreme forms are so combined that it is hard to assign them to one or the other. The form of the body is most distinctive, and the range of variation of this does not overlap; that of the head and arms is a little less distinctive and overlaps slightly. The size of the ocellus is again sharply differentiated. The form of the eye-spot varies considerably from a well-formed dark circle containing a lustrous annulus to a stage in which the annulus is simply laid over a faint reticulation (Leipzig Museum). The brown reniform interocular spot is indifferently present or absent in the two species. The sculpture varies from a coarse rough warty surface to a fine shagreen of acute granules, and, though I think the coarsely tuberculate condition is more characteristic of *ocellatus*, the variation is very considerable and of little diagnostic value. The form of body, head, etc., are quite independent of sexual differentiation. The larger Kagoshima specimen (*areolatus* 5, p. 119; type of *Octopus brocki*) is very interesting. It is much darker and larger than usual, and, though a female, it has enlarged suckers.

Attention should be drawn to the unusual shortness of sector A of the web in Appellöf's specimen of "*ocellatus*."

For a discussion of the position of *O. membranaceus*, Q. & G., see p. 126.

Octopus (Octopus) ocellatus, Gray.

(Plate III, fig. 1, VII, fig. 2; Text-figs. 33–35, 37A.)

? *Octopus sinensis*, Orbigny (1840, p. 68, Pl. 9); ? *Octopus fang-siao*, *id.* (*l.c.*, p. 70); *Octopus ocellatus*, Gray (1849, p. 15), Brock (1887, p. 610); Ortmann (1888, p. 662); ? *Octopus areolatus* (part), Joubin (1894, p. 28); *Octopus ocellatus*, Joubin (1898, p. 22); *Polypus ocellatus*, Berry (1912*b*, p. 393); ? *Polypus areolatus*, *id.* (*l.c.*, p. 393 (pars), fig. 1); ? *Polypus fang-siao* (Orb.), Sasaki (1920, p. 172).

Holotype.—In Brit. Mus.

Specimens seen.

(*a*) In Brit. Mus.

One (♂) from "China": 1928.12.6.5. (Old Collection), (Type). Two (♀♂) from Chee Foo: 74.1.24.2. One (♂) from the Inland Sea, Japan: 1902.11.19.9. Two (♂♂) from Santiao, China: 1928.3.29.3–4. One (♂) from "N. China": 63.5.1.5.

(*b*) In U.M., Leipzig.

One (♀) from Japan (Doflein).

(*c*) In Z.M., Berlin.

One (♀) from Kobe (Gottschke). One (? sex) from Hong Kong.

(*d*) In R.M., Leiden.

One (♀) from Japan (syntype of "*areolatus*").

Distribution.—China Seas (Gray); Japan (de Haan, Berry); ? Amboina (Joubin).

Description.—The type specimen may be described as follows. The mantle is very wide, short and plump, the greatest width being apical. The head is much narrower than the visceral sac. The arms are in the

order 3.2.4. = 1., 4. = 3.2.1., 4.2.1.3., the longest being usually 81% of the total length. The mantle-aperture is moderately wide (B–C). The suckers are abruptly enlarged in the male on the second and third arms, where their diameter is 21% of the mantle-length. The enlarged suckers are usually very conspicuous, as they are much taller than the rest. The sections of the web are subequal in depth and the web is rather shallow, being 21–27% of the arms. The sculpture consists of numerous low, coarse, usually multifid tubercles which approximate to the rosette type of *pallida*. The ocellus lies rather nearer the eye than to the edge of the web, and is very large and distinct, being 35–26% of the mantle in length. It is of the same type as that of *areolatus*, the inner pale ring being very lustrous. There are 7–8 gill filaments in each demibranch. The hecto-

Fig. 33.—*Octopus ocellatus*. Type. Hectocotylus. × 5·7.

Fig. 34.—*Octopus ocellatus*. Penis. × 5·5.

Fig. 35.—*Octopus ocellatus*. Oviduct. (Chee Foo.)

cotylus is slender and very simple. The calamus is scarcely apparent, and the median groove very weak. It is about 6% of the arm-length. The penis resembles that of *Octopus vulgaris*. The funnel-organ in the type agrees very closely with Berry's figure (1912, p. 394), except that it is more slender. It is **W**-shaped, and all the limbs are very thick. The inner limbs are vertical and the outer are somewhat bent. Berry (1912*b*, p. 393 and foll.) describes two specimens which more or less agree with the type. In one the arms are 69% of the length, in the other they are 77%. One of them has a heavily papillate skin with stellate tubercles, and it has an interocular patch as in *areolatus*. The coloration of the second seems to be of a special type.

Maximum size.—203 mm. (Berry).*

Remarks.—The nomenclature and identity of this species are discussed on p. 117.

* Berry's larger specimen (304 mm.) is of uncertain identity.

Octopus (Octopus) areolatus, Orbigny.

(Plate 7, fig. 1; text-figs. 36, 37.)

? *Octopus membranaceus*, Quoy & Gaimard (1832, p. 89); ? *Octopus sinensis*, Orbigny (1840, p. 68, Pl. 9); ? *Octopus fang-siao*, *id.* (*l.c.* p. 70); *Octopus areolatus*, *id.* (*l.c.*, p. 65, after de Haan MS.), Hoyle (1886, p. 86, Pl. III, figs. 6–7); ? *Octopus ocellatus*, Appellöf (1886, p. 8, Pl. 1, figs. 1–3); *Octopus areolatus*, Brock (1887, pp. 608–11), Ortmann (1888, p. 662); *Octopus brocki*, *id.* (*l.c.*, p. 645); *Octopus areolatus* ?, Jatta (1889, p. 64); ? *Octopus areolatus*, Joubin (1894, p. 28), *id.* (1898, p. 22); *Polypus areolatus*, Wülker (1910, p. 6), Massy (1916A, p. 193); ? *Polypus fang-siao*, Sasaki (1920, p. 172).

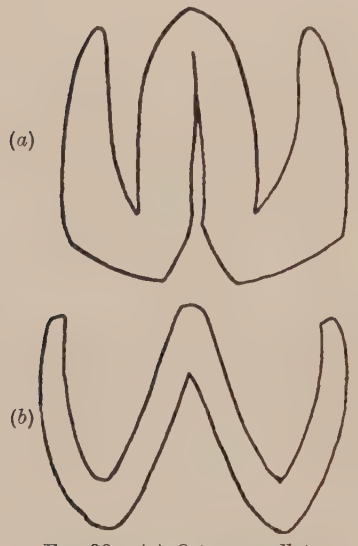


Fig. 36.—(*a*) *Octopus ocellatus*. (Type.) (*b*) *O. areolatus*. (" Challenger.") Funnel organs.

Fig. 37.—*Octopus areolatus*. (" Challenger.") Radula.

Holotype.—In R.M., Leiden.

Specimens seen.

(*a*) In Brit. Mus.

One (♂) from the " Ki " Islands, South of Papua [sc. = Kei Islands, Banda Sea].

(*b*) In U.M., Leipzig.

One (♂) from Japan (Doflein). Two (♀♀) from Tokio (Ijima).

(*c*) In R.M., Leiden.

One (♂) from Japan (Type).

(*d*) In the Museum of the Academy of Natural Sciences, Philadelphia.

Three (♂♂♀) from " Polynesia."

(*e*) In U.M., Strasbourg.

Two (♂♂) from Kagoshima (types of *Octopus brocki*, Ortmann).

Distribution.—Japan (de Haan; Appellöf; University Museum, Leipzig; Zoological Museum, Berlin; 's Rijks Museum, Leiden); Kei

Islands (Hoyle); Hong Kong (Copenhagen Museum, *fide* Hoyle); Amboina (?) (Joubin); Misaki, etc., Japan (Wülker); Gulf of Martaban (Massy); ? locality (Jatta).

Description.—The mantle is rather narrow and oblong (43–76%), and the head is similarly narrow and usually narrower than the mantle. The arms are short (68–78%), their order being uncertain (3214; 3421; 4231; 4321 are found). The suckers are small in the female (9%); but they show a marked increase in the male, in which they average 22%. The web is subequal (C being the deepest section), and is rather deep (20–33%). The skin is usually closely shagreened with fine warts or somewhat larger warts, which may be absent over a greater or less part of the dorsal surface. The ocellus consists of a dark oval patch 14–24% of the mantle in length, and contains a pale iridescent ring. There is a pale brown spot between the eyes (Brit. Mus., Wülker). The ocellus lies either nearer the eye (Hoyle), half-way between web and eye (Massy), or nearer the web (Appellöf). There are 10–12 filaments in each demibranch. The funnel-organ is of a simple **W**-shape, and its limbs are slender. The radula is normal. It has an A_2 seriation; the admedian is long and narrow, and the second lateral has a very curved base. The hectocotylus tends to be long and narrow (4·4–13% of the arm), and its calamus is very small. It is not easy to reconcile the length of the hectocotylus in Massy's specimen with that of Brock (*q.v.*). The distal part of the oviduct is long (33% of the mantle).

Maximum size.—(?) 245 mm., "*brocki.*"

Remarks.—I am very uncertain as to the position of Joubin's *areolatus* (1894). The data are not of such a nature as to allow of very satisfactory analysis.

The nomenclature and identity of this species are fully discussed on p. 117.

Octopus (Octopus) areolatus var. **ovulum,** Sasaki.

(Plate II, fig. 2.)

Polypus ovulum, Sasaki (1917, p. 364 (? *Octopus ocellatus, areolatus.*).

Syntypes.—In the Science College, Tokyo.

Distribution.—Japan [Tokyo Fishmarket] (Sasaki); Macclesfield Bank, China (British Museum); Vargat Reef, East Africa (British Museum).

Specimens seen.—Two (♂♀) from the Macclesfield Bank, China, and Vargat Reef, East Africa: 94.9.5.5. and 89.1.30.1.

Description.—The two specimens are closely covered in the dorsal area with more or less uniform rounded tubercles (some being a little larger than the rest). Each possesses a circular ocellus, which in C 330 contains a bluish ring (the other being damaged) in the usual position. Each exhibits six longitudinal dorsal and dorso-lateral dark stripes. The hectocotylus is long, and the ligula very slender with a well-marked groove. The penis is very like that of *ocellatus* (Fig. 33), and seems to agree with that rather vaguely described by Sasaki, in that the penis

itself is long and slender, the appendix swollen and elliptical. It receives subterminally the duct of Needham's organ.

Maximum size.—150 mm. (Sasaki).

Remarks.—Sasaki was plainly in doubt as to whether his species could be distinguished as a separate form. It is some satisfaction to be able to place this interesting form correctly. The two specimens in the national collection resemble each other closely in spite of their remote places of origin. Their proportions are as follows :—

	m.l.	m.w.	ioc.	1.	2.	3.	4.	%.	Gills.	Suckers.	Web.	%.	Hect.
C 330(♀)	17	64	70	35	38	38	39	69	? 7	8	9–10–12–10–10	30	—
C 332(♂)	24	66	62	51	52	50	—	68	? 7	18	12–13–16–16–15	30	9%

These two specimens agree very well with *areolatus* (there are a few points of difference), and, as far as Sasaki's description goes, they agree with his *ovulum* pretty closely. I do not think then we can regard *ovulum* as a distinct species. Several of the special features of these specimens and Sasaki's species are no doubt the expression of immaturity. But I regard the peculiar stripes as a very distinctive feature and worthy of systematic recognition. Sasaki's description is rather unsatisfactory as, while it supplies very useful anatomical information, it does not give precise details as to external parts. But I think the " dark round patch containing a small cobaltic ring " lying nearer the umbrellar margin, the arms which are 73% of the total length, the sculpture " shagreen-like " and composed of uniform warts and the " oblong " body, all point to its being conspecific with *areolatus*.

Octopus (Octopus) sinensis, Orbigny (? **Octopus ocellatus** or **areolatus**).

" Octopus tchang-iu "—*Octopus sinensis*, Orbigny (1840, p. 68, Pl. 9); *Octopus fang-siao, id.* (*ib.*, p. 70); *Polypus fang-siao*, Sasaki (1920, p. 172).

Distribution.—Japan.

Remarks.—The apocryphal species bearing the names quoted above are briefly mentioned by Orbigny, who quotes the " Encyclopédie Japonnaise," in which their habits, etc., are said to be described. Although common and an article of diet in Japan at the time of the composition of the " Encyclopédie," they cannot be satisfactorily recognized as referable to any of the better-described Japanese species. Sasaki includes both *O. areolatus* (?) and *O. ocellatus* in the synonymy of *O. fang-siao* without giving any reason. Possibly he has heard those two forms alluded to by the local name. Otherwise there is no means of identifying them except the characteristic eye-spot found in *sinensis* and in *areolatus* and *ocellatus*. It might seem a fair inference that the Japanese author, of whose description Orbigny made use, was figuring representatives of *areolatus* or *ocellatus*, as they are probably the commonest Japanese species with the eye-spot. But in view of the fact that at least two species similarly equipped are found in Japanese seas, the description is inadequate. *O. fang-siao* is said to differ from the Tchang-iu (*O. sinensis*) only in its smaller size. The method of fishing for these

forms and the peculiar habits exploited by the fishermen, as related in the "Encyclopédie," are discussed on p. 22.

Octopus (Octopus) pulcher, Brock.

Octopus pulcher, Brock (1887, p. 607).

Holotype.—In the University Museum, Göttingen.

Specimen seen.—One (♀) from Amboina, Univ. Museum, Göttingen (Type).

Distribution.—Only known from the type-locality, Amboina.

Description.—The mantle is oval and smoothly rounded posteriorly. The eyes are very prominent. The mantle-aperture is wide (C.). The arms are rather short (70%) and more or less subequal; they have the formula 4.3 = 2.1. The suckers are not specially enlarged. The web is deeper posteriorly than anteriorly (C = D.E.B.A.) and attains a maximum depth of 28% of the longest arms. It is continued up the arm as a narrow membrane. There are nine filaments in each demibranch. The surface is smooth. Over each eye are three conical cirrhi and there are four dorsal cirrhi, which are arranged in a diamond-shaped pattern. The colour is a dark greyish-brown marbled with irregular dark brown marks. There is a circular bluish-black ocellus surrounded by a narrow yellowish-white border, which is again surrounded by a narrow dark one placed in front of each eye between the lateral arms. The distance to the ocellus from the eye is a little less than the diameter of the ocellus, that between the latter and the edge of the web a little greater.

Total length.—50 mm.

Remarks.—The type specimen is small and probably immature; it may be a young example of one of the species with larger and more elaborate ocelli. The variation in the latter noted by Berry in *O. bimaculatus* (q.v.) must incline us to discount its taxonomic value. The type specimen might be a young example of *areolatus.* The deeply incised dorsal sector of the web and the order of the web and arms render this very likely.

Octopus (Octopus) (?) membranaceus, Quoy & Gaimard.

Octopus membranaceus, Quoy & Gaimard (1832, p. 89, Pl. 6, fig. 5), Orbigny (1840, p. 43, Pl. X, fig. 4; XXVIII, figs. 1–4), Tryon (1879, p. 124); *Amphioctopus membranaceus,* Fischer (1882, p. 333); *Octopus membranaceus,* Brock (1887, pp. 609, 612), Ortmann (1888, p. 662); "*Octopus areolatus,* Joubin (1894, p. 28)," (pars), Berry, (1912*b*, p. 397); *Polypus membranaceus,* Berry (1912*b*, p. 397); *Octopus membranaceus,* Odhner, (1917, pp. 12, 70).

Type.—(?) In M.H.N., Paris (? Holotype.)

Specimen seen.—One specimen (? sex), in M.H.N., Paris ("New Guinea, Q. & G., 1829"), (? Type).

Distribution.—Port Dorey, New Guinea (Quoy & Gaimard); China

and Japan (?) (Tryon); Amboina (?) (Joubin); Cape Jaubert, etc., Australia (Odhner, 12–42 ft.).

Description.—The type description and figure reveal a presumably young form with ovoid mantle edged by two lateral membranes which reach neither the apex of the sac nor the anterior end. These membranes are not seen in the (presumed) type. From Orbigny's description (*l.c.*, p. 43) the original membrane must have been fortuitous. The head is very clearly marked by nuchal and infra-ocular constrictions, and is wide with very prominent eyes. The arms are in the order (Orbigny) 2.3 = 4.1, and are about 73% of the total length. The web is very low (? 12%) and apparently equally developed between all the arms. The surface is granular, and there are ocular and cephalic cirrhi. At the base of the lateral arms on each side there is an ocellus thus described by Orbigny—" une très large tache noire ovale . . . dans cette tache est un cercle de même forme, plus petit, formé d'une ligne élevée qui paraît avoir été blanche: et au centre se trouve une tache plus claire." For a discussion on the relation of this form to the *areolatus* group see below; for measurements, see p. 50.

Maximum size.—c. 80 mm. (" 3 inches 2 lines " Q. & G.).

Remarks.—This form has been included in the synonymy of *areolatus* by several authors, and I am inclined to think that they may be correct in this view. As the original specimen was obviously young and differs in certain respects from *areolatus*, it seems to me better to keep it as a doubtful form. Very unfortunately the specimen in the Paris Museum which is probably to be regarded as the type is in a poor condition, and does not allow of a satisfactory diagnosis. The ovoid or cylindrical body, granular sculpture, short arms and eye-spot suggest that this may be *areolatus*. Some of the characters, viz. the low equal web and prominent head, may be due to immaturity. The ocellus according to Orbigny's description is not exactly like that of any variant of *areolatus* or *ocellatus* which I have seen. It is to be noted that in Quoy and Gaimard's figure the body is cylindrical and has a width index of 59%, while from Orbigny's table of dimensions the width-index is $\frac{17}{14} = 82\%$ and indicates a more globular shape. This is probably a young specimen of an intermediate individual of the very variable *ocellatus-areolatus* group.

D. Group of **Octopus pallida.**

Octopus (Octopus) pallida, Hoyle.

(Text-fig. 38.)

? *Sepia boscii*, Lesueur (1821, p. 101, *nomen nudum*); ? *Octopus variolatus*, Blainville (1826, p. 186); ? *Octopus boscii*, Orbigny (1840, p. 68); *Octopus boscii*, var. *pallida*, Hoyle (1885, p. 223), *id.* (1886, p. 82, Pl. 1, 3, fig. 2), Brazier (1892, p. 3), ? Joubin (1894, p. 32 (part)), Pritchard and Gatliff (1894, p. 241); *Polypus boscii*, Hoyle (1904*b*, p. 195); *Polypus rugosus*, Massy (1916A, p. 189); *Polypus variolatus*, Berry (1918, p. 278, Pls. LXXIX, LXXX, LXXXI, figs. 2–3; LXXXII, figs. 1–4); *non Octopus* (or *Polypus*), *boscii*, Lesueur, *boscii*, Orb., *boscii*, Gray, Auctt.).

Holotype.—In Brit. Mus.

Specimens seen.—Two adult specimens (♂ (Type) ♀) from Twofold Bay, New South Wales and Bass Straits (1889.4.24. 19–20.). One juvenile specimen from the former locality: 1889.4.24.21.

Distribution.—(The identity of some of the forms mentioned by early workers as "*Octopus boscii*" being uncertain, these records are not taken into account.) New South Wales and Bass Straits (Hoyle), in 150–38 fathoms; Tasmania, in 56–80 fathoms, Bass Straits (deep water (?)—100 fathoms), W. Australia (Great Australian Bight) in 80–200 fathoms (Berry), Victoria (Pritchard and Gatliff); ? Amboina (Joubin); Ceylon (pearl Banks) (Hoyle).

Description.—In this summary the data for Joubin's (1894) specimens are not included. The size of the hectocotylus and character of the sculpture make it highly improbable that these specimens are referable to *O. pallida*.

The shape of the mantle is rather variable. The type and some of

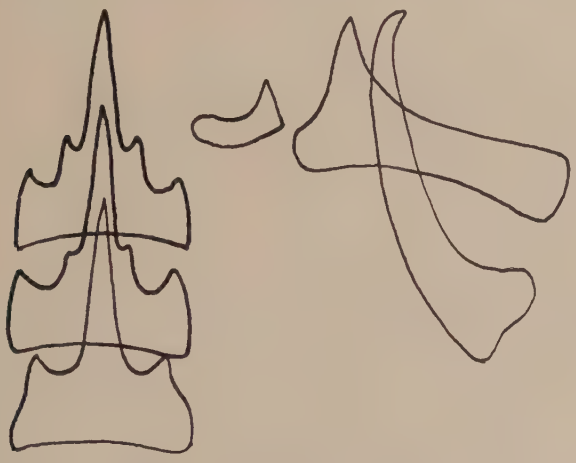


Fig. 38.—*Octopus pallida*. Radula.

Berry's specimens have a very broad sac, as wide or wider than the mantle in length. Others of Berry's specimens are oblong. This difference is not correlated with differences in sex. The head is always much narrower than the body. The arms are usually in the order 4321, and, on an average, 68–75% of the total length. The suckers are moderate in size, and in the male there is no abrupt enlargement. The web in the type is subequal and about 24% of the arms in depth. In two of Berry's specimens there is a marked disparity in size between sectors A and E, E being much the deeper. The sculpture consists of an elegant pattern of rosette-shaped tubercles closely set all over the body and web, the tubercles being cleanly cut and standing up in marked relief from the surface of the skin. Berry notes rows of enlarged tubercles on the dorsum. The eyes are surmounted by a large branched cirrhus accompanied by some smaller ones. The mantle-aperture is narrow (type B). There are 8–9 filaments in each demibranch. The funnel-organ is paired

and consists of two V-shaped pads with equal limbs. The radula in the type has a rhachidian tooth with more or less regular A_4 sequence. The first lateral has a long curved base and high cusp. The second lateral has a long base, no entocone, and a moderate heel. The third lateral is straight and much recurved at the tip. In Berry's male specimen the seriation of the rhachidian seems to be asymmetrical. The adlateral is not well shown, but it seems to have a high cusp. The second lateral has no entocone and a very small heel. The third laterals are rather straight. The hectocotylized arm is a good deal smaller than its fellow. Its ligula is described by Berry as large and powerful. Actually it is 9–12% of the arm in the type and Berry's male. It is long and narrow with markedly infolded sides.

Maximum size.—? 375 mm. (Berry).

Remarks.—The name "*Octopus boscii* (Lesueur)" has been very largely used for a characteristic Australian octopus, the skin of which is covered completely with neat, rosette-like tubercles. Dr. S. S. Berry (1918, p. 278) has recently considered the question of the correct name for this species. He rightly points out that "*boscii*," Lesueur, cannot be accepted, as it was published without description or figure. He advocates the use of *O. variolatus*, de Blainville (1826). This name was applied to a species described from Péron's original notes on a specimen, probably that referred to by Lesueur as his *boscii*. I cannot agree with Dr. Berry that *variolatis* should be used for the form subsequently known (*e.g.* by Hoyle) as *boscii*. The type is, as far as I can ascertain, lost, and the description contains nothing that is not applicable to a great many species. Moreover, in one respect, viz. the length of the arms, de Blainville's species is definitely unlike that described under the name *boscii* var. *pallida* by Hoyle. Péron actually referred the specimen to *rugosus* of Bosc. Dr. Berry thinks that *Octopus boscii* (Orbigny (1840, p. 68)) has some nomenclatorial status, but rightly points out that Orbigny only transcribes Blainville's unrecognizable description of *variolatus*. Berry further points out (p. 281) that Gray's *boscii* (1849) is more completely described, and the description is "in some accord with our specimens." Examination of Gray's type shows that it is identical with the form described and well figured in 1852 by Gould as *Octopus tetricus*. Gray's *boscii* cannot be shown to be the same as Orbigny's *boscii*, so that the latter is unrecognizable as a species. In 1885 Hoyle described the Australian form with rosette-like tubercles as *Octopus boscii*, var. *pallida*. Whether this is the form described by Lesueur, Blainville and Orbigny we do not know; but it is certain that the name *pallida* emerges as the right one to be given to the form in question. Massy's suggestion (*l.c.*), that Hoyle's *pallida* is a form of *rugosus* seems to me without justification. It is true indeed that the sculpture of some undoubted *rugosus* tends to become rosette-like as in *pallida*; but this occurs only very sporadically, and I have never seen any forms transitional in other respects between *rugosus* and *pallida*. On the other hand, I think that *O. pallida* and *O. tetricus*, while substantially different, have several characters in common (see p. 100).

Octopus (Octopus) californicus, Berry.

(Text-fig. 39.)

Polypus californicus, Berry (1911, p. 590), *id.* (1912*a*, p. 286, Pl. XXXV, figs. 6–7; Pls. XXXVIII, XXXIX, figs. 1–2; Pl. XL., figs. 2–3).

Holotype.—U.S.N.M., Washington.

Distribution.—Monterey, S. Catalina I. and San Diego, California, in 95–1,041 fathoms.* Only known from the type area.

Specimen seen.—One (♀) from S. Catalina I., California (iuv.), U.S.N.M., 214659.

Description.—In preparing the table of dimensions (p. 46) I have obtained the length from the apex to the eyes by subtracting 10 mm. from Berry's " tip of body " measurement, a procedure which gives us approximately the required distance. Berry does not give the exact designation of the 3rd arm (? R. or L.), so that it is not possible to calculate the length of the ligula accurately. I have used the length given in making this calculation; but, as that may be of the left arm, the figure obtained may be too low.

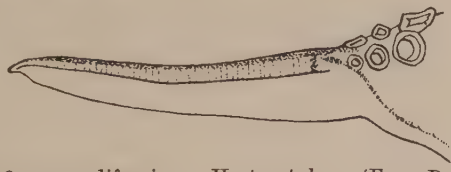


Fig. 39.—*Octopus californicus.* Hectocotylus. (From Berry, 1912*a*.)

The body is short and plump and nearly as broad as long. The head is broad, but narrower than the body. There is a slight, but definite " neck." The arms are rather short (on an average 74% of the total length). Their order is very variable and inconstant, but seems to be $\begin{matrix}2.4\\1\end{matrix}\Big\}\ \begin{matrix}3.1\\4\end{matrix}\Big\}$. Some of the suckers are markedly enlarged in the male. The web is uniform, but D and E are slightly shallower than the rest. The web is moderately deep, viz. 22–25% of the arms, and is continued along the latter to their extremities. The surface is covered with very characteristic stellate papillae, which are obsolete and smaller on the ventral surface. The colour is a " livid pinkish-brown, lighter below." The mantle-aperture is wide. The funnel is rather long, and is very largely adherent to the head. The funnel-organ is composed of two thick and stumpy V-shaped pads, the outer arms of which are shorter and narrower than the inner. The ink sac is present. The hectocotylus is described as " relatively enormous, thickened and massive," by Berry. From his figure it would appear to be long and of the elongate *hongkongensis* type, rather than " thickened and massive."

Habits, etc.—Berry states that this is the most common offshore Octopus of S. California. Whether it should be regarded as abyssal is doubtful. Apparently the example taken in water over 1,000 fathoms is very much contracted, and its identity is by no means certain. The

* See " Habits," etc.

average maximum depth of the ten hauls in which the species was taken is 199 fathoms.

Remarks.—The exact position of this form is a little obscure. It is quite obviously distinct from the other Californian Octopods. The short arms, and double funnel-organ, are like those of a Bathypolypoid form. The hectocotylus is rather of the *O. hongkongensis* type, and its affinities may be with that group, though its arms are shorter on the average than those of any member of the latter.

Octopus (Octopus) dofleini (Wülker).

(Text-fig. 40.)

Polypus dofleini, Wülker (1910, p. 7, Pl. II, figs. 1, 2; Pl. III, fig. 10); Berry 1912*b*, p. 391, discussion).

Holotype.—In the University Museum, Munich.

Distribution.—Todohokke (or Hokkeido). Only known from the type locality.

Description.—The body is markedly oval, the head short and rather narrow (I cannot understand why Wülker says "breit" (cf. his fig. 1 and the dimensions, *l.c.*, p. 8)). The arms are about 75% of the total length, and in the order 2.1.3.4. or 2.1.4.3. There is a difference of about 100 mm. between the longest and shortest arm. The suckers are not referred to as specially enlarged. The web is not fully described; but it seems to be largest in the lateral sectors, smallest ventrally. The funnel is very short and reaches up to the middle of the web of the fourth arms. The hectocotylized arm is 50 mm. shorter than its fellow. The ligula is slender and pointed. It has a well-marked, but narrow groove, and is about 6·2% of the length of the arm. The wrinkled dorsal surface of the body bears some isolated warts, which become large and knob-like near the eyes. The under surface is smooth. The colour is not mentioned.

Fig. 40.—*Octopus dofleini*. Hectocotylus. (After Wülker) fig. and text.

Maximum size.—570 mm.

Remarks.—There is not a very full description of this species. I agree with Berry that it is closely related to the *O. hongkongensis* group (*Paroctopus*), from which it differs in its shorter arms and hectocotylus. The body and head are narrower than those of the type of *O. hongkongensis*, and the sculpture is by no means like that of the latter, being evidently coarser. Wülker compares this species with *O. punctatus*, Gabb. I think that the status of this species really depends on the result of fuller analysis of the *O. apollyon–O. hongkongensis* group.

Octopus (Octopus) gilbertianus, Berry.

(Text-fig. 41.)

Polypus gilbertianus, Berry (1912*a*, p. 284, Pl. XXXV, figs. 4–5; Pl. XXXVI, fig. 2; Pl. XXXVII).

Distribution.—Behm Canal and Stephens Passage, S.E. Alaska, in 41–188 fathoms.

Holotype.—In U.S.N.M., Washington.

Description.—The body is of a rounded pyriform (? globular) shape, and is wider than it is long. The head is short and broad, but narrower than the body. There is hardly any "neck." The eyes are large and rather protruding. The arms according to Berry are in the order 2.3.4.1. (but see table in Berry, *l.c.*, p. 285), and are about 77% of the total length. On the level of the edge of the web (?) some 4–8 suckers are enlarged (only males obtained). The web is deepest laterally, and A is deeper than E (but cf. cotype). Its relative depth cannot be ascertained with any accuracy; but it is certainly over 21% in the type. The hectocotylized arm is very much shorter than its fellow. The ligula is described as large and stout; but the figure shows it as long and slender. It is deeply grooved and seems to be furnished with many laminae (not shewn in figure 41), though these are obscured by wrinkling. The funnel is free for a little less than half its length. The surface is covered everywhere with numerous minute rough papillae, which as usual are more obscure ventrally. There is a single large supraocular tubercle. The colour (spirit specimens) is deep brownish-claret, slightly mottled with a darker shade above.

Fig. 41.—*Octopus gilbertianus.* Hectocotylus. (After Berry, 1912*a*; see p. 131.) × *c.* 2·5.

Maximum length.—355 mm.

Remarks.—This species has obvious affinities with *Paroctopus*; but for the time being its status is obscure. It is hoped that full particulars of the funnel-organ, radula and web will be forthcoming.

E. Group of **Octopus tenuipulvinus.**

Octopus (Octopus) tenuipulvinus (Sasaki).

Polypus tenuipulvinus, Sasaki (1920, p. 182, Pl. 24, fig. 5).

Holotype.—In U.S.N.M., Washington.

Distribution.—Sagami Sea, in 70 fathoms.

Description.—The body is compact and as wide as long, the head being a little narrower than the body and constricted above and below. The arms are unequal and have the formula L. 2.3 = 1.4, R. 1.2.3.4., the longest arm being about 85% of the total length (calculated). The suckers are small and rather sparsely set, none of them being specially

enlarged. The sections of the web are of equal depth, but the web is "poorly developed," the length not being given. There are no arm-membranes.

The surface of the body is wrinkled and finely tessellated with numerous grooves, and beset with tubercles which are distributed "almost as in *P. vulgaris*." There are apparently no ocular cirrhi. The funnel-organ is composed of two hook-shaped parts, a very uncommon form.

The vaginae are thick and straight. The coecum of the stomach is L-shaped.

Maximum length.—155 mm.

Remarks.—This form, which is possibly still immature, is specially characterized by the rare form of the funnel-organ (cf. p. 156) and the grooving of the skin. Sasaki likens the arrangement of the tubercles to that seen in *O. vulgaris*. It is difficult, however, to see what special arrangement is indicated. From the context one would infer that the tubercles are not particularly numerous, so that it is not easy to see how their arrangement is like the numerous close and irregular warts characteristic of European *O. vulgaris*.

F. Group of **Octopus fusiformis.**

Octopus (Octopus) fusiformis, Brock.

Octopus fusiformis, Brock (1887, p. 601, Pl. XVI, figs. 1, 2); *Octopus pisiformis* (sic), Hoyle (1897, p. 367); *Polypus fusiformis*, Massy (1916A, p. 203).

Holotype.—In the University Museum, Göttingen.

Distribution.—Amboina (Brock); Palk Straits, S. India (Massy).

Description.—There seems to be little ground for doubting the correct identification of Massy's specimens. The mantle-sac is very long and slender, and certainly in Brock's specimen it is very nearly the narrowest on record (width-index 26%). The "neck" is very narrow and the eyes are prominent. The mantle-aperture is very wide (C). The arms vary very much in their size, but the first seem to be the longest and attain a length of 79–72% of the total length. Massy (*l.c.*, p. 203) says, "arms of about five times the length of the body," but this is not borne out by her figures. The web is about 20% of the arm-length according to Massy, but lower according to Brock; its shape varies, one of Massy's specimens having the various sectors equal, the other having sector A deepest. In Brock's specimen E is deeper than A. The funnel is long and conical and only free for one-third of its length. The hectocotylus is spoon-shaped and extraordinarily small, being ·8% of the third arm. The sculpture is confined to the dorsal region of mantle, head and web; Massy does not state if the sculpture of her specimens assumes the reticulate pattern (like that of *Ocythoe*) on the ventral surface reported by Brock. The colour is in general dark brownish above and pale below.

Maximum size.—(?) 267 mm. (Massy).

Remarks.—This very striking form is one of the narrowest of all

Octopods, and, as Brock says, it is like a *Loligo* without fins. Massy queries whether the species may not be identical with the specimen of "*Cistopus indicus*" (Orbigny), which Rapp used for his MS. description of that species, it being evident that Orbigny's description of that specie is founded on two different species (*v.* p. 182). Neither of the specimens of *Cistopus* figured by Orbigny, however, is narrow enough to suggest identity.

Octopus (Octopus) teuthoides, n. sp.

(Plate II, fig. 4; text-fig. 42.)

Holotype.—In Brit. Mus.

Specimens examined.—One (♀) from Walla Island, New Hebrides (F. A. Philipps), (Holotype): 1928.3.28.1.

Distribution.—Only known from the type locality.

Description.—The mantle is spindle-shaped, its breadth being 31% of the length. The head is long and narrow, its width being about 21% of the mantle-length. The arms are very short, about 57% of the total

Fig. 42.—*Octopus teuthoides.* Funnel-organ. × 9.

length and in the order 1.2.3.4. The suckers are small and prominent. The web is equally developed and of insignificant depth. There are practically no arm-membranes. The funnel is well-developed, and is free for about $\frac{1}{3}$ of its length. It reaches barely to the level of the eyes. The locking-ridge seems to be unlike that normally found in the genus, and the pallial depression is very deep. The funnel-organ is well developed and W̄-shaped. The most striking feature in the pallial cavity is the very marked reduction of the adductor pallii medialis, which is reduced to a mere filament. The surface of the body is smooth. The ground-colour is pale yellow anteriorly and dorso-laterally. There are a number of pale red chromatophores. A ring of these encircles the whole anterior end of the mantle, and a double row is found up the arms.

Dimensions.—Mantle-length, 16 mm.
Mantle-width, 6 mm.
Head-width, 4·2 mm.
Arms, R. 1, 22 mm.
2, 16 mm.
3, 14 mm.
4, 12 mm.
Web % arms, 17 %.

Habits.—As the type specimen was "caught by searchlight" it is probably nocturnal like many other Octopods.

Remarks.—In the shape of its body this form approaches *O. fusiformis*, Brock. It differs from the latter (*a*) in the extraordinarily short arms (very short even for a small specimen), (*b*) the absence of sculpture, (*c*) the colour, and (*d*) the fact that its suckers are closely spaced not widely alternating. I know no other species which approaches it in its narrowness and the shortness of its arms; so that in spite of its apparent immaturity it should be described as new.

Octopus (Octopus) amboinensis, Brock.

(Text-figs. 43–44.)

Octopus amboinensis, Brock (1887, p. 598); *Octopus Amboinensis* Joubin (1894, p. 31).

Holotype.—In the University Museum, Göttingen.

Specimen seen.—One (♀) from Amboina, in the University Museum, Göttingen (Type).

Distribution.—Amboina (Brock, Joubin).

Description.—This species is only very slightly known. The rather meagre accounts given by Brock and Joubin are in substantial agree-

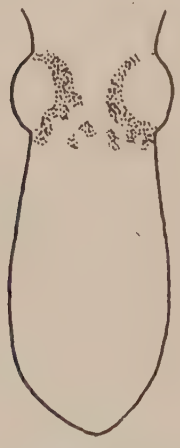


Fig. 43.—*Octopus amboinensis.* (Type.) × 3.

Fig. 44.—*Octopus amboinensis.* Funnel-organ. (Type.)

ment except as regards the colour of the species. The mantle-sac is narrow (41–44), ovoid and posteriorly pointed (Brock), "fusiform" (Joubin). The eyes are prominent and large. The pallial cavity is widely open (C). The arms are of moderate length (75–77%), and in the order 3.2.4.1. Brock states that the suckers especially in the oral region (? unteren Teil) are widely alternating. The web is very poorly developed, and more or less equal in all its sections. It is 7–10% of the arms in length, and is continued up the arm as well-developed extensions. The funnel

is free for only a quarter of its total length. The funnel-organ is W-shaped and all its limbs are slender. There is no surface ornamentation. The colour according to Brock was uniform clear ochreous yellow, with a patch of large violet chromatophores between the eyes. Joubin describes a more complex colour-pattern, the chief features of which are (1) a pair of crescentic, deep green patches above the eyes, and (2) a double row of small red chromatophores disposed evenly up the first and second arm-pairs. There is a single row on the third arm and a few basal ones on the fourth.

Maximum length.—About 101 mm. (Joubin).

Remarks.—The type is a small specimen which may be a young example of another species. It is not unlike *O. elegans* (q.v.). Joubin comments on the elegance of this form and notes that it is almost hyaline when alive. He states that it "ne manque pas de rapports avec *Parasira catena*" (*Ocythoe tuberculata*), a point noted by Brock. As in the case of *O. elegans* this similarity is purely superficial. The species may be referable to *Macrotritopus*.

G. Group of **Octopus defilippi.**

Octopus (Octopus) defilippi, Vérany.

(Text-figs. 45–49.)

Octopus Defilippi, Vérany (1851, p. 30, Pl. 11, figs. D, F); *Octopus de-filippi*, Targioni Tozzetti (1869, p. 20); *Octopus De Filippi*, Tiberi (1880, p. 11); *Octopus defilippi*, Hoyle (1886, pp. 8, 216); *Octopus De Filippi*, Carus (1890, p. 460); *Octopus Defilippi*, Fra Piero (1895, p. 268); *Octopus defilippi*, Jatta (1896, p. 221, Pl. 4. etc., monograph); *Octopus de-filippi* Bergmann (1903, p. 104, fig.); *Octopus defilippi*, Marchand (1907, p. 361, fig. 37); *Octopus Defilippi*, Lo Bianco (1909, p. 649); *Polypus defilippi*, Massy (1916*a*, p. 196), Cerruti, (1921, p. 239), *Octopus Defilippi*, Naef (1923, p. 707); *Octopus defilippi*, Robson (1925, p. 105); *id.* (1926, p. 187, fig. 16); *Octopus de filippi*, Winckworth (1926, p. 321).

Type specimen.—(?) In Musée d'Histoire Naturelle, Nice. (? Syntype.)

Specimens examined.

(*a*) In Brit. Mus.

Three (♂♀♀) from Naples; 90.5.21.341–3. One (♂) from Nice: 89.2.11.12. Two (♂♀) from Calcutta: 88.8.15.4–5. One (♂) from Masqat, Arabia: 1928.8.8.1.

(*b*) In M.H.N., Paris.

One (? sex) from Cape Verde (1874).

(*c*) In U.M., Leipzig.

One (♀) from Naples.

(*d*) In U.M., Jena.

One (? sex) from Messina.

Distribution.—Mediterranean (Vérany); Masqat (Brit. Mus.); Mergui (Massy); Ceylon (Winckworth); Calcutta (Brit. Mus.).

Up to 1916 *O. defilippi* had not been recorded outside the Mediterranean. In that year Massy described a specimen from Mergui which she assigned to this species. After analysing her figures and examining

her description critically I agree with her diagnosis, although she gives no particulars of the web, radula, etc. Winckworth (*l.c.*) records the species from the pearl-banks of Ceylon, but gives very few data. The two specimens from Calcutta listed above are only referred with great hesitation to this species. They agree with the Mediterranean form in general; but the arms are shorter (80%), and the male has enormous suckers on the second arms, the diameter of which is 20% of the length of the mantle. These specimens are young and measure 20 mm. and 15 mm. in mantle-length. The specimens from Aden are very like the Mediterranean *O. defilippi*. On the whole I am inclined to believe that this species is found in Oriental waters; though it is very remarkable that there are so few records of its occurrence outside the Mediterranean. The only record

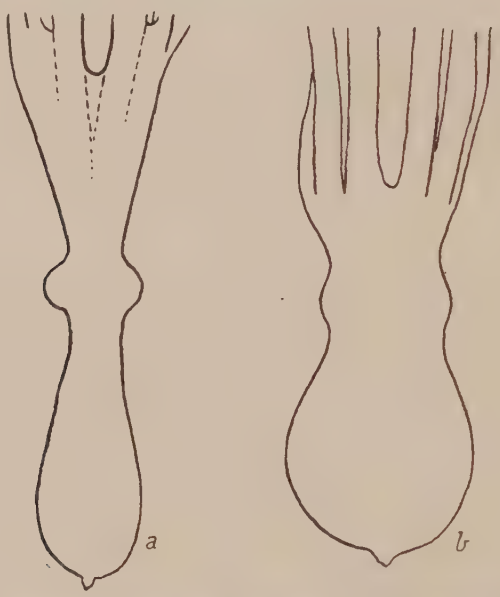


Fig. 45.—*Octopus defilippi*. (*a*) Var. *dama*. (*b*) Typical form. × 1·1.

from the Atlantic is provided by a specimen from Cape Verde, in the Paris Museum.

Definition.—The mantle is either saccular or elongate-ovoid. The latter phase is usually found associated with a greater prominence of the eyes, which may become disproportionately larger than the head. The arms are mostly in the order 3.2.1.4., and attain an average length of 84% of the total length (range in four specimens, 83–86%). The suckers are not conspicuously enlarged in the male, except in the male Calcutta specimen (see above) in the British Museum, and their average size is 11% of the mantle-length. The mantle-aperture is rather widely open (Type B–C). The web is very shallow, being 7–13% of the longest arms, and its sections are subequal in depth. The gills have 9–10 filaments in each demibranch. The funnel-organ is **W**-shaped (Jatta, *l.c.*, taf. 24, F. 11). The radula has been figured and described several times (*v.* bibliography). It is usually characterized by the absence of ectocones on the rhachidian,

a very uncommon feature in *Octopus*. Specimen No. 4, however, has well-developed ectocones with a symmetrical seriation (A3–4). The status of this form is discussed below.

The *genitalia*. The male organs are figured by Marchand (*l.c.*, p. 362), and dissection of specimen No. 1 showed very little difference from that type. The penis is variable (fig. 49) in form, and in our specimens is not expanded at the outer extremity as in Marchand's figure. The male system on the whole is not different significantly from that of *O. vulgaris*.

The female system (fig. 138) has not been figured previously. Bergmann (1902, p. 104) has described what is unmistakably a receptaculum seminis, a structure hitherto reported among the Octopoda only in the Argonautidae (Brock, 1882).* This statement requires careful examina-

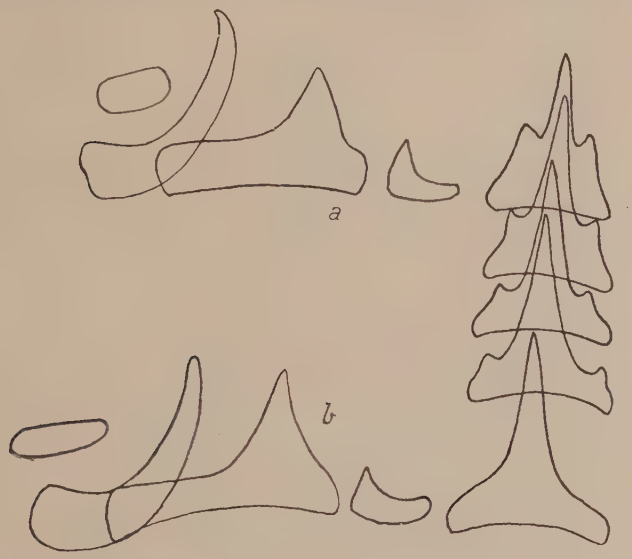


FIG. 46.—*Octopus defilippi*. Radula. (*a*) Var. *dama*. (*b*) Typical form.

tion. In the two female specimens available I found the condition illustrated in Bergmann's figure. The distal part of the oviduct is very long, the proximal part extremely short. In both specimens the distal oviduct is arranged in a characteristic fashion, and, more noteworthy, its proximal end is somewhat expanded and contracts abruptly before it enters the oviduct gland. There is thus some approach to the double oviduct seen in *Cirroteuthis*, *Opisthoteuthis* and in *Octopus aegina* (Robson, 1928*a*, fig. 4). Now Bergmann, on the other hand, states that there is on the oviduct of *O. defilippi* "dicht bei der Mündung des Oviduktes in die Ovarialkapsel" a "fast kugelige Aussackung desselben [oviduct]" which is about a quarter of the size of the whole ovary. It is not clear from the context whether this "Aussackung" is the oviducal gland itself or a separate structure lying between the oviducal gland and the ovary. His specimen was young, and it is possible that the "Aussackung" is

* Brock (*l.c.*, p. 595) says of *Octopus* and *Eledone*—"Receptacula seminis sind ganz verloren gegangen."

additional to the oviducal gland. In the female specimens which I have examined there is no expansion between the oviducal gland and the ovary. In short, I am inclined to believe that Bergmann's " Aussackung " is the oviducal gland itself.

If that view is right, it opens up another question. Is the " oviducal gland " really a " receptaculum " in all Octopods? There is an observation which renders this likely. Racovitza (1894, p. 35, fig. 2, *O. vulgaris*) describes and figures the spermatophore passing down the oviduct as far as the " bulla " (= oviducal gland) and as coming to rest there. It

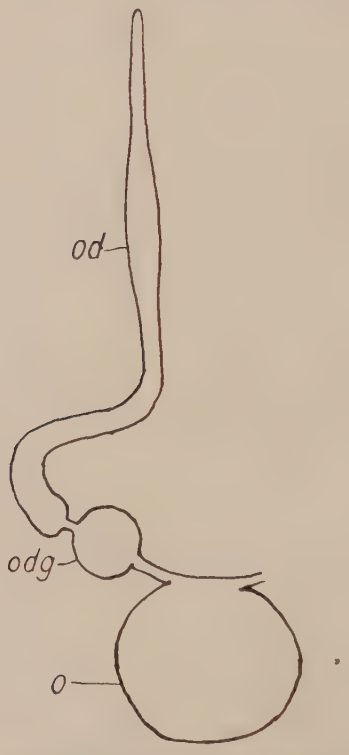


Fig. 47.—*Octopus defilippi*. Reproductive organs: *od*, oviduct; *o*, ovary; *odg*, oviducal gland. × 2·25.

seems to me likely that the sperm reservoir may be emptied at that point in most Octopodinae, and its contents received into the " oviducal gland." The whole subject is plainly one for special research, and in default of more exact knowledge we must suspend judgment as to the value of Bergmann's discovery.

The *hectocotylus* has been figured by Jatta (*l.c.*) and Naef (*l.c.*). It is of the *vulgaris* type, has a very short calamus, and is usually about 3% of the whole arm.

The skin is usually smooth. Naef (*l.c.*, p. 709) speaks of the occurrence of " vergänglich " warts. There is, indeed, usually a growth of small warts around the eyes; but I have seen no examples with warts in

other positions. In the living animal the colour is brownish or pale golden yellow ornamented with an irregular meshwork formed by the aggregation of small chromatophores. The size is relatively small, and it rarely exceeds 5 cm. in mantle-length (Naef, *l.c.*, p. 709). Marchand (*l.c.*, p. 57) gives a maximum (over-all) size of 6·5 cm., which is a little small.

Maximum size.—240 mm. (Jatta).

Variation.—The most striking feature in the variation of this species is the difference between the form with narrowly-ovoid mantle and prominent eyes and that with more bursiform mantle. Extreme examples of the two states are seen in text-fig. 45.

Vérany (*l.c.*) described and figured a form with a subcircular visceral sac, having only a single example at his disposal. Jatta (*l.c.*) stated

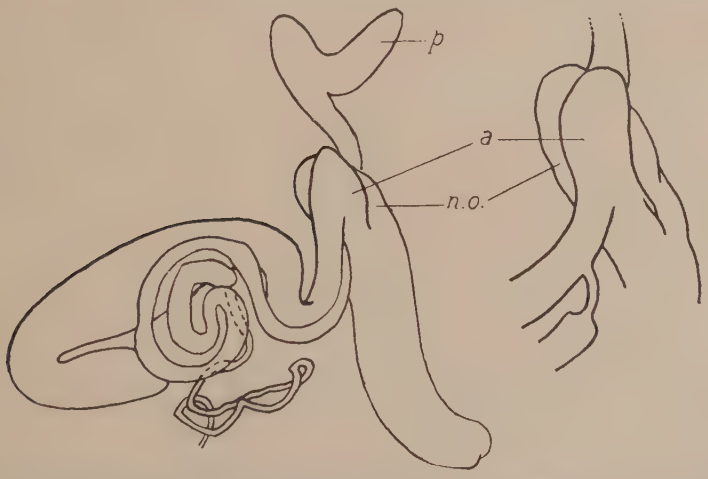


Fig. 48.—*Octopus defilippi.* Male reproductive organs : *a*, appendix; *n.o.*, Needham's organ; *p*, penis.

clearly that the living animal is slender and contracts to the subcircular form on preservation. Naef (*l.c.*) does not mention this. He contents himself with observing that the mantle is normally like that indicated in his figure 420, *i.e.* elongate ovoid, but that it sometimes is ovoid or saccular. I assume he dissents from Jatta's view. Personally, though I agree that Jatta had every opportunity of verifying his statement, I am very sceptical about its truth; for of the four preserved specimens in our collection two are slender, two saccular. Both our long-bodied forms are females; but Massy's male specimen is long-bodied, so that this feature is not influenced by sex.

I am otherwise unable to point to any striking variation in this form. The web, arms, etc., of the specimens examined are rather uniform. There is plainly a tendency for the chromatophores to be aggregated in masses tending to a dark hue, and one of the specimens in the British Museum is heavily reticulated with dark brown.

Habits.—Jatta (*l.c.*), Naef (*l.c.*), Lo Bianco (*l.c.*) and Marchand (*l.c.*)

allude rather casually to the habits of this species. Jatta states that it lives in water of 6–30 m. in depth; Vérany (*l.c.*, p. 32) says it is found down to 200 m. Marchand thinks with Vérany that it lives in deeper water and only comes into the coastal zone to breed. Both authors agree that it prefers sandy or muddy bottoms. It apparently lurks among the stems of *Posidonia* and other plants. Naef (*l.c.*) figures a specimen hiding in a clump of *Myriozoum* "dem er angepasst erscheint," a statement which requires verification, as there is no proof that the form with prominent eyes and small head, which Naef thinks resembles the *Myriozoum*, is found exclusively on that Polyzoan. Lo Bianco (*l.c.*, p. 649) states that it disappears from the Gulf of Naples in the summer and is only caught in winter and spring. Fertilization has been recorded in March, the eggs in May, and young 11–15 mm. long in November (Cerruti). Several authors note the frequent occurrence of autotomy of the arms of this species.

Fig. 49.—*Octopus defilippi*. Penis. × 5·5.
(*b*) With spermatophore in distal portion.

Remarks.—This is an easily recognizable form when compared with the other Mediterranean species. It is less easily distinguishable from certain Oriental forms. The nomenclatorial history has been simple. The unicuspidate rhachidian, occurrence of forms with long and very narrow body and prominent eyes and the very small equal web are markedly divergent from the main *Octopus* type. As the specimen from Nice in the British Museum, however, has a multicusped rhachis, and as the two other characters are not in any sense unique, I refrain from creating a separate subgenus for this form. I suspect, however, that this may be necessary, as in some respects (though not in all) the species is very distinctive and unlike other true *Octopus*. Much depends on a study of the receptaculum seminis (see p. 137).

I consider that the elongate form requires a distinctive status, and consequently propose the following name:

Octopus (Octopus) defilippi, var. **dama,** n. var.

Octopus defilippi, Jatta (1896, Pl. 4, fig. 2).

Holotype.—Specimen No. 4 (98.5.21.341), in the Zoological Department, British Museum.

The mantle is very narrow, its width being under one-half of its length. The eyes are large and prominent and the web is longer in proportion (20% as compared with 13%) than in the typical form. The rhachidian tooth of the radula bears symmetrical ectocones.

Octopus (Octopus) niveus, Lesson (? = **filamentosus,** de Blainville).

(Text-fig. 50*a*, *b*.)

Octopus niveus, Orbigny (1826, p. 144, *nomen nudum* (without description)); *Octopus niveus*, Lesson (1830, p. 239, Pl. 1, and 1 bis); *Octopus aculeatus*, Orbigny (1840, p. 53, Pls. 7, 8, 23); *Octopus harmandi*, de Rochebrune (1882, p. 73); not *Polypus aculeatus*, Orbigny, Hoyle (1904*b*, p. 194) (= *horridus* fide Hoyle (1907*b*, p. 454); *Polypus aculeatus*, Massy (1916A, p. 191).

Type specimen.—Unknown; that of *aculeatus* in M.H.N., Paris.

Specimens seen.

(*a*) In M.H.N., Paris.

One (♂) from ?. One (♂) from Manilla (Perrotet). Two (♂♀) from Poulo Condoro, Cochin China (type of "*O. harmandi*").

(*b*) In Senck. Inst., Frankfurt a/M.

One (♀) from the Red Sea.

Distribution.—Manila, Philippines (Orbigny); Bora Bora Island, (Lesson); Red Sea (Frankfurt); Cochin China (M.H.N., Paris); Burma (Massy); Indian Ocean (Goodrich, 1896).

Description.—The specimen in the Paris Museum ascribed to Perrotet and labelled "Manilla," and therefore likely to be the one figured and described by Orbigny as the type of *O. aculeatus*, does not agree with the description. Orbigny evidently drew up his description very carelessly, as he gives a total length of 230 mm. with 190 mm. for the longest arm and 17 mm. for the mantle! The Perrotet specimen is 245 mm. long and is rather long and narrow in the body, not globular as appears in Orbigny's figure. Our definition must be qualified by this ambiguity. I believe that Massy's specimens are correctly named. The mantle is globular or ovoid (111–45%); the head is narrower than the body (62–48%); and there is a fairly well-marked neck. The arms may be as much as 90%, the range (including Orbigny's figures) is 83–90%. Their order is 4.2.3.1. (Orbigny), 2.4.3.1. or 3.2.4.1. (Massy). The suckers are conspicuously (Paris) or moderately (Massy) enlarged in the male. The web is very shallow 4–12% and subequal. The funnel-organ is **W**-shaped. The ligula is very small, 1·4–4% of the third arm, but it has a well-developed calamus and median groove. The surface is covered with tubercles and cirrhi on the dorsal surface of the head and web. Lesson and Orbigny both show the dorsum of the mantle as mainly free of cirrhi, but the Perrotet specimen is very rough all over the dorsum, and in Massy's specimen the cirrhi seem to extend all over the latter. The cirrhi are notably congregated round the eyes. Lesson's specimen was entirely colourless ("white"); that of Orbigny was a deep brownish-violet above becoming yellowish rose below. Massy's specimens were dull liłac "heavily marked on the dorsal surface with minute purple-black chromatophores."

Maximum size.—In Massy (*l.c.*, No. 3), 255 mm. (223 + 32).

Variation.—Owing to the ambiguity mentioned above as to the measurements of Orbigny's specimen and the paucity of material it is impossible to discuss the variation. The most noteworthy feature is the occurrence of the narrow Perrotet specimen. The white form recorded by Lesson may have been produced by some accident of preservation.

Remarks.—According to Orbigny (1840, p. 55) *Octopus aculeatus*, as described by him in 1840, was figured and described by him in 1825–6. This description was never, as far as I can find, published; nor is the date of the plates of the "Céphalopodes Acétabulifères," if they were published in advance of the text, available. On the other hand, he and Férussac, published the name "*Octopus niveus*, Nob." (without description or indication) in 1826 for the specimen from Bora Bora Island, which in 1840 he declared was conspecific with his *aculeatus*. In the meantime Lesson in 1830 had published a description and figure of "*Octopus niveus*." As, according to Orbigny (*l.c.*, p. 55) Lesson's species is identical with his own *aculeatus* (1840) there can be no course but to adopt Lesson's name. The rejection of an old standing name like *aculeatus* is regrettable,

(*a*) (*b*)

Fig. 50.—*Octopus niveus*. (*a*) Funnel-organ. (*b*) Hectocotylus.

but the case for Lesson's *niveus* is plainly unassailable. At the same time I must point out that Lesson's type is not in the Paris Museum and cannot be traced, though the original of Orbigny's *aculeatus* is preserved. For the identification of Lesson's *niveus* and Orbigny's *aculeatus* we are dependent on (*a*) Orbigny's own statement and (*b*) a comparison of the figures published by the two authors, in which the close correspondence of the absolute and relative size of the arms and the characteristic sculpture is well seen.

The very long arms, low equal web, small ligula and extremely cirrose body are distinctive. *Octopus filamentosus* is, however, very closely allied, and it may be necessary to treat *Octopus niveus* as a synonym, especially as Wülker (see p. 143) has obtained specimens of *filamentosus* with cirrous skin. I have included here *harmandi*, de Rochebrune, after a study of the type in the Natural History Museum, Paris. The following details of this specimen may be given :—Mantle-length 30 mm. Mantle-width 70%. Head-width 60%. Arms 4.2 = 3.1. Arms 87%. Suckers abruptly enlarged (♂), 23%. Web, DC = B.A. = E subequal, 10%. Hectocotylus 1·3%. Funnel-organ W-shaped, with very narrow limbs and free for $\frac{1}{15}$ of the length. The surface is covered in one specimen

by wrinkles; in the other it is more definitely sculptured on the head, web and anterior part of the body with irregular ridge-like warts. Sparse arborescent cirrhi are present. The hectocotylus resembles that of *niveus* in every detail.

Octopus (Octopus) filamentosus, Blainville.

? *Octopus aranea,* Orbigny (1826, Pl. V. of " Céph. Acét."); *Octopus filamentosus,* Blainville (1826, p. 188); *Octopus aranea,* Orbigny (1840, p. 57, Pl. V), Martens (1880, p. 727); *Polypus aranea,* Wülker (1913, p. 459).

Type specimen.—In M.H.N., Paris (? Holotype.)

Specimens seen.

(*a*) In Brit. Mus.

One (♀) from unknown locality: 68.6.8.24.

(*b*) In M.H.N., Paris.

One (♀) from unknown locality. One (♀) from Mauritius (Matthieu), (? Type).

(*c*) In S.B.I., Frankfurt.

One (♀) from S.E. Celebes.

(*d*) In Z.M., Berlin.

One (♀) from Adelaide, One (♀) from Mozambique.

Distribution.—Mauritius (Blainville, Orbigny), Celebes (S.B.I., Frankfurt), Mozambique (Martens) and Adelaide (Berlin Museum). Actually Hoyle (1886, pp. 217, 220) cited this species as from his South African and Pacific Insular regions. The former included Mauritius, the only known place of occurrence at that time. He gives no details as to the occurrence of the species in the " Pacific Insular " region.

Description.—I include in the description without much hesitation data obtained from a specimen which, in spite of some distortion of the mantle, very much resembles Orbigny's figure. The mantle is ovoid in the type, but elongate in one of Wülker's specimens. There are moderate praeocular and postocular constrictions. The head is very much narrower than the body, and the eyes are moderately prominent. The arms are very long, 86–90% of the total length. In Wülker's second specimen they are six or seven times as long as the mantle. The web is subequal, sector D being slightly longer than the rest in the British Museum specimen. It is very shallow in the type and only a little longer in the London specimen. The surface in the type specimen is smooth. In one of Wülker's specimens it is apparently warty and in the London specimen, the surface of which is rather damaged, it is wrinkled and very probably sculptured with some form of tuberculation. The colour is blackish on the dorsal surface in the type as it probably was in the London specimen; inside the web it is white.

The mantle-aperture is narrow (type B). The funnel-organ is W-shaped, the extremities of the limbs being rounded. There are 7–8 filaments in each demibranch. The hectocotylized arm is said by Wülker to be of the same length as its fellow, and to bear a very small, spoon-shaped ligula.

Maximum size.—215 mm. (Orbigny (*l.c.*), see footnote p. 57).

Remarks.—The very long and finely drawn out arms and their order,

the exceedingly shallow web and general appearance of this species seems to indicate a close affinity with *Octopus niveus*. We do not as yet know enough about the variation of the sculpture and colour in these forms, nor indeed about such important features as the web-form, funnel-organ and hectocotylus, to enable us to discuss their relationship very intimately.

As in the case of *Octopus niveus* and *Octopus aculeatus*, "*Octopus aranea*" seems to have been figured by Orbigny about 1826, but no evidence is forthcoming that the figures for the plates of the "Céphalopodes Acétabulifères" were ever published before the text. In the latter work Orbigny states that his *aranea* and Blainville's *filamentosus* are the same species, so that Blainville's name has priority, though his description is far less complete than Orbigny's.

H. Group of **Octopus australis.**

Octopus (Octopus) australis, Hoyle.

(Text-fig. 51.)

Octopus australis, Hoyle (1885, p. 224), *id.* (1886, p. 88, Pl. III, figs. 4–5), Brazier (1892, p. 57), Pritchard and Gatliff (1898, p. 241); *Polypus australis*, Massy (1916*b*, p. 149); *Polypus*, cf. *australis*, Berry (1918, p. 276, Pl. LXXVIII, figs. 1–2; Pl. LXXXI, fig. 1).

Type specimen.—In Brit. Mus. (? Holotype.)

Specimens examined.—Two specimens (♂♀) from Port Jackson: 89.4.24.28–9. Four (♂♂♀♀) from Spirits' Bay, New Zealand: 1919.12.30. 42–3.

Distribution.—Sydney in 6–15 fathoms (Hoyle); George's Beach, New South Wales (Brazier); Spirits' Bay, New Zealand, in 11–20 fathoms (Massy); Gabo Island, Victoria, in ? 200 fathoms (Berry); Pt. Philipps Head, Victoria (Pritchard and Gatliff).

Description.—The body is rather rounded and saccular, the head being markedly smaller. The eyes are small. The arms are rather short (72–76% of the total length) and more or less subequal, the order being 2.3.1.4., 3.2.1.4., etc. There is little difference in length between the various arms, except in Berry's specimens. The suckers are rather small and are not enlarged in the male. The web has the arrangement B.D.A.C.E. or B = C.D.A.E. In Berry's specimen the sectors A and E are equal in depth. The web is rather deep, being fully 33% of the arm-length (see anon). The dorsal surface is covered closely with granular tubercles. Ocular cirrhi are present, and in the New Zealand specimen some of the dorsal tubercles are much enlarged. The ground-colour is ochreous and is mottled and spotted with light or dark brown. The spots are aggregated to form transverse bars on the arms in Massy's example, as in Brock's *Octopus robustus* (p. 211). The mantle-aperture is narrow (C). The funnel-organ is **W**-shaped, the median limbs being rather closely opposed, and all the apices of the limbs are more or less acute. There are 8–9 filaments in each demibranch of the gills in the type specimen, 6–7 filaments in the New Zealand examples. The radula has an A_2 seriation in the type specimen and a New Zealand specimen; the first lateral has a wide base and low cusp; the second lateral a moderate heel, long base and no endocone; the third laterals are moderately curved and have

rather wide elongate bases. In Berry's specimen the rhachidian seems to be asymmetrical, the second laterals have no heel (or are orientated in the preparation so as to show none), and the third laterals are scarcely curved and the bases are small. The ink sac is normally developed. The hectocotylized arm is somewhat shorter than its fellow. The ligula is large (nearly 11% of the arm) and of the *Bathypolypus* type, being thick, deeply excavated and its sides being heavily inrolled.

Maximum size.—(*a*) Berry's specimen about 140 mm. (*b*) Type 87 mm.

Variation.—There is a marked difference in the web between Berry's specimen, on the one hand, and the type, and Massy's example on the other. Sections A and E are equal in the Victorian specimen, and in the others A is deeper than E. The body is evenly rounded in the latter, not wider apically as in the type. The radula in Berry's specimen differs in certain points. Berry also speaks of his specimen as though it had finer "surface papillation." Judging from Berry's figure and statement, the most striking difference in the sculpture is that the papillae are angular in Berry's specimen and tend to coalesce to form short ridges. Berry does not mention the characteristic colour-bars seen on the arms in the type and "Terra Nova" specimens; nor are they apparent in his figure.

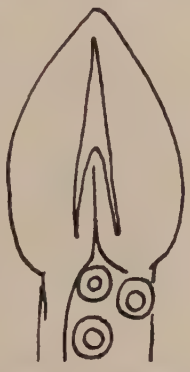


Fig. 51.—*Octopus australis*. Hectocotylus. × 7·5.

Remarks.—Massy compares this species with *Octopus globosus*, Appellöf; but I think the differences between the two species are substantial and important. She also says, "the types of *Polypus duplex* (Hoyle) bear a strong likeness to the various-sized specimens which are here referred to *Polypus australis*, and I think that it is probable that they will eventually prove to be the young of that species." The indirect comparison made by Massy between *Octopus macropus* and *australis* seems to me to be based on a misconception of the real constitution and character of *macropus*. Berry (*l.c.*, p. 278) is likewise unable to detect the relationship. Personally I think that *australis*, while offering points of similarity to several other species, is quite distinctive and not likely to be confused with them. A comparison of Massy's New Zealand specimens with the type specimen shows that the former agrees in most important respects with the latter. Massy's adult specimen is a male and the larger type specimen is a female, and this may account for the difference in bodily proportion between them, the male being rather globular and having a broader head. Concerning Berry's specimen I am less certain. It is not possible to use the standard method of comparison, as Berry does not give the apex-eye measurement, but from his excellent figure it would seem that the bodily proportions are more or less similar to those of the type. There are indeed certain differences (cf. Variation), but, except in the size of the web, I am inclined to think that they do not warrant the exclusion of Berry's specimen from this species. The short subequal arms, large, coarse hectocotylus and deep web suggest affinities with the Bathypolypodinae.*

* Since writing the above remarks I have compared the types of this species and *Joubinia campbelli* (p. 190). I consider that they are identical.

UNCLASSIFIED FORMS.

Octopus (Octopus) furvus, Gould.

Octopus furvus, Gould (1852, p. 475, fig. 589).

Type specimen.—? U.S.N.M., Washington (cf. Gould, *l.c.*, p. vi). (? Syntype.)

Distribution.—Rio Janeiro (market and fishermen).

Description.—The body is elongate and somewhat pear-shaped. The head is very long and the eyes " rather large " (? fig.), but scarcely prominent. The arms are subequal and very long (86% of the total length) and slender. The web is deepest laterally. It is shallow and about 20% of the arms. The suckers are " large." The tip of the funnel does not reach the level of the eyes. The surface is smooth " or faintly wrinkled." The ground-colour is ochreous; but it constantly varies (? in a single individual), " being nearly black or mottled with ash colour or entirely ash-coloured. The underside is paler and shaded with orange-coloured dots. Cupules milk-white."

Remarks.—This species has never been again seen or recorded since Gould's description. It seems to be a well-characterized form, the excessively long subequal arms, low and weakly developed web, narrow oval mantle and dark ashy colour forming a very distinctive assemblage of characters. Superficially it reminds me of *O. macropus*, but I do not think it can be referred to that species, even as a well-marked variety. Gould's description is of a specimen forty-six inches over all, so that it must rank with our largest species.

Octopus (Octopus) filosus, Howell.

Octopus filosa, Howell (1867, p. 240, Pl. 14).

Distribution.—" Santa Cruz Island " (only known from the type locality). There are several " Santa Cruz " islands, mostly in the Pacific. I suspect, however, that the West Indian Island of that name is meant.

Type specimen.—(? Holotype) in Mus. Ac. N. Sci., Philadelphia.

Description.—The body is elongate and conical, apparently rather like that of a *Sepia*, and rounded at the apex. The eyes are very prominent, and there are well-defined subocular and supraocular constrictions. The head is slightly narrower than the body. The arms are all characterized by the fact that for over half of their length the distal extremity is reduced to a thread-like filament. They are in the order $3 = 4.2.1.$, and the longest are about 81% of the total length. The web appears to be very shallow (from the figure), possibly about 14–15% of the arms. The suckers are said to be uniserial on the thread-like part of the arms. Otherwise they are " large," and on the second arms as many as eight adoral ones are uniserial. The funnel extends just beyond the middle point of the eyes. The surface is smooth with " dorsal beards," and there are six " ocular beards." The colour is reddish; " around the mouth and

the inner surface of the arms white, approaching a cream colour" (Howell).

Maximum size.—200 mm. (from Howell's data).

Remarks.—This species, represented by specimens of a maximum body-size of about 38 mm., is not very well characterized, and since the first description there have appeared no fresh data. The outstanding feature is the reduction of all the arms to a filiform condition for nearly one-half to two-thirds of their length. I am not certain, however, that this may not be an adventitious feature, as I have occasionally seen this condition in one or more arms, *e.g.* of *O. macropus*. The elongate body and prominent eyes are distinctive.

This is a littoral species and is said by Howell to be very active.

Octopus (Octopus) tehuelchus, Orbigny.

Octopus Tehuelchus, Orbigny (1835, p. 27, Pl. I, figs. 6–7), *id.* (1840, p. 55, Pl. 17, figs. 6 and 6*a*); not *Octopus megalocyathus*, Cunningham (1871, p. 474, as Hoyle 1889, p. 218); not *Octopus tehuelchus*, Hoyle (1886, p. 89); *Octopus Tehuelcus*, [sic] Rochebrune and Mabille (1889, p. H6); ? Corsi (1900, p. 494); ? not *Polypus tehuelchus*, Hoyle (1912, p. 278, figs. 4–5); ? *Octopus tehuelchus*, Robson (1925, p. 105, radula).

Syntypes.—Not traced.

Specimens examined.—I have examined several specimens in the Museums of Paris and Leipzig attributed to this species, but I am not at all satisfied that they are correctly named.

Distribution.—St. Blas Bay, Patagonia (Orb.); ? Falkland Is. (Hoyle, 1912); ? not Nicaragua (Copenhagen, as Hoyle, 1886); ? Uruguay (Corsi).

Description.—The body is short and purse-like ("presque rond," Orb.), rather broader than it is long. The head is somewhat narrower than the body. The eyes are moderately prominent and there is a weak "neck." The arms are in the order 4.3 = 1.2., and are about 80% of the total length. The web, to judge from the figure, is about 20–25% of the arms, though Orbigny says, "a little less than one-tenth." The funnel, if Orbigny's sketch (1840, fig. 6*a*) is accurate, is curiously placed, as its base is *more anterior than the level of the eyes*; (this may be due to accident). The surface is smooth. The colour is rather a deep blackish-brown above, becoming bluish below. The ventral surface of the arms is bluish.

Maximum size.—167 mm. (Orbigny).

Habits, etc.—Little is known concerning this species, which Orbigny describes it as a rare, littoral form. The stomach-contents of a single individual consisted only of fragments of other molluscs.

Remarks.—At present it is quite impossible to obtain a clear idea as to the identity of this species. Orbigny's descriptions are slight and it is not easy to be sure if any of the various records from South America (*e.g.* those of Corsi (*l.c.*), Melvill & Standen (1901, p. 43)) are correct. At present we have only the original description to guide us. Hoyle's account of the hectocotylus and radula (1912) of a specimen from the Falkland Island cannot be confidently applied to *tehuelchus*, Orb., as,

upon examination, these specimens prove to be very like the form described here as *Enteroctopus eureka*. Orbigny's species cannot be so far satisfactorily recognized among the described forms of *Enteroctopus* and *Joubinia* (see pp. 175, 187).

Hoyle's West Indian record (1886) was plainly an error, and the specimen is described elsewhere (*O. joubini*, p. 161). I am very sceptical about the identity of a specimen from Nicaragua in the Copenhagen Museum which was referred to in this species (Hoyle, 1886, p. 89).

Note.—I have recently found in the Museums of Jena and Berlin specimens of a species that evidently ranges from Peru to Patagonia and is not referable to the described forms of *Joubinia* and *Enteroctopus*. This may eventually prove to be Orbigny's *tehuelchus*.

Octopus (Octopus) schultzei, Hoyle.

(Text-figs. 52–53).

Polypus schultzei, Hoyle (1910*a*, p. 261, text-fig. 1, Pl. V*a*, figs. 1–3).

Holotype.—In Z.M., Berlin.

Specimens examined.—One ♂ in Z.M., Berlin (? type).

Distribution.—Angra Pequeña, S.W. Africa. (Type locality.) Among rocks in shallow water.

Description.—The body is small and ovoid; as it is very much distorted it is difficult to distinguish its true shape. Its width appears to be about

Fig. 52.—*Octopus schultzei.* Funnel-organ.

Fig. 53.—*Octopus schultzei.* Hectocotylus. (After Hoyle and type.)

96% of its length. The arms are in the order R: ? 2.3.4.1; L: 3.1.4.2.; but they have been very much damaged. The maximum arm-length appears to be 83% of the total length. The suckers are markedly enlarged on some of the arms and attain a maximum diameter of 22%. The web is somewhat asymmetrical and has the formula L: A.B.C.D.E; and R: B.C.A.D.E. It is rather deep, about 32% of the arms in length. The funnel is small and scarcely reaches a third of the way towards the top of the web. *The radula.* The rhachidian seems to have a B_3 or B_4 seriation. The first lateral has a very prominent cusp. The second lateral has a very high cusp also, a narrow base and no ectocone on the heel. The third laterals are short, very stout, and have enormous bases. The funnel-organ is very singular and unlike that of any true Octopus (cf. fig. 52). There are nine filaments in each demibranch.

The *hectocotylus* (fig. 53) is very peculiar. It appears to have no calamus; the ligula is spatulate and apparently devoid of a median

groove, the latter being represented by a pit at the extremity, the greatest diameter of which is transverse to the main axis of the organ. The penis is also remarkable. It has a very long, free extremity, 12 mm. in length, and there are no traces of a diverticle. The surface of the body is smooth, and the colour is a dull purple, which, as usual, is lighter on the ventral surface.

A fuller examination of the type reveals in the very peculiar funnel-organ and penis additional features of interest, and I am inclined to think that the association of very distinctive features here described merits special recognition.

Maximum size.—245 mm. (Hoyle.)

Remarks.—I agree with Hoyle that this form cannot be easily identified with any known species. The only specimen is a male, and some of its outstanding features (hectocotylus, suckers) are exclusively male characters. Nevertheless, the combination of other external characters exhibited (smooth body, deep web, funnel-organ) is not found in any other form from this area.

Octopus (Octopus) patagonicus,* Lönnberg.

Octopus patagonicus, Lönnberg (1907, p. 50).

Holotype.—In the Zoological State Museum, Stockholm.

Distribution.—Punta Areñas and Puerto Churruca, Patagonia. Collected on kelp on the shore.

Description.—The body is broad and stout, its width being nearly 100% of its length. The head is much narrower than the body. The arms are in the order $\begin{cases} 2.1.3 = 4 \\ 1.2.3 = 4' \end{cases}$, and the longest are about 83% of the total length. The suckers are "very large in the middle of the arms." All the web proportions are not given, but section B is the deepest and about 20% of the arms; section D is the next deepest, and between the ventral arms the web is entirely absent. The funnel is thick and blunt. The surface of the skin is obscured by wrinkling. The colour is "dark violet."

Maximum length.—70·5 cm. (?).

Remarks.—This may eventually prove to be referable to the very ambiguous *O. tehuelchus*, Orb., but at present it is better to regard them as distinct. The arms, though in both cases tending to be subequal, are in a different order, and those of *patagonicus* are longer. The web of *patagonicus* is relatively shorter, and the colour is different. On the other hand, the general form seems to be alike, and the web in both cases is longer than the visceral sac. The outstanding difference seems to be the complete absence in *O. patagonicus* of the web in section E. I think that, had this occurred in *O. tehuelchus*, Orbigny would probably have mentioned it. On the other hand, future investigation may show that this form is referable to *Enteroctopus*, in which group my *E. eureka* comes tolerably near it, though it cannot be regarded as conspecific. The ambiguous *O. pentherinus*, R. and M., may be compared.

* Since writing the above account I have seen the type of this species. I believe it is conspecific with *Enteroctopus megalocyathus*, Gould. It will be discussed in a forthcoming publication.

Lönnberg's younger specimen was anomalous in having only seven arms, no trace being found of the eighth.

Octopus (Octopus) pusillus, Gould.

(Text-fig. 54.)

Octopus pusillus, Gould (1852, p. 478, Pl. 48, fig. 591*a*, *b*); *Octopus pusillus*, Tryon (1879, p. 112 (= *O. mollis*)); ? *Octopus pusillus*, Ortmann (1888, p. 644, Pl. XXI, fig. 1); ? *Polypus pusillus*, Hoyle (1904*a*, p. 16, Pl. 4, fig. 5; Pl. 5, fig. 1); *Polypus pusillus*, Berry (1912*b*, p. 389).

Syntypes.—? In U.S.N.M., Washington.

Distribution.—Mangsi Island (China Sea) (Gould). ? Kagoshima (Japan) (Ortmann). Acapulco, Cocos Is. (E. Pacific), Mariato Point & C. Mala (W. Panama) (Hoyle), in 493–978 fathoms.

Description.—The mantle is "sub globose," and the head, which is about as wide as the mantle, is separated from the latter by a marked "neck." The eyes are prominent. The arms are in the order 1.2.3.4., and are more or less subequal. From Gould's text they are 66% of the total length, but in his figure they are longer. The web from the figure seems to have the formula C = A, B = D. ? E. It is one-third (33%) of the arm-length. The surface is smooth and the colour slatey. Hoyle describes the radula and hectocotylus of his C. American forms. The details of the former are given in the table on p. 48. The hectocotylus is rather long (8·8% of the arm), and according to Hoyle "the centre of the spoon-shaped portion forms a rounded elevation." This elevation is seen in the somewhat ambiguous figure (Pl. 4, fig. 5). Hoyle also figures the radula in which the rhachidian has a B4 seriation. The second lateral seems to be devoid of both heel and entocone. The rest of the figure is a little problematical.

Fig. 54.—*Octopus pusillus.* Hectocotylus. (After Hoyle.)* × 5·8.

Maximum size.—(Of type) 75 mm. Hoyle gives a maximum size of 85 mm. See below as to Ortmann's specimens.

Habits, etc.—Nothing is known of the habits of this form. It is very important to notice that all Hoyle's specimens are from deep water, 493–978 fathoms. Of course, if they were not taken in a closing net, they may actually have been living nearer the surface.

Remarks.—As Berry (*l.c.*) states, "the identity and important characters of this species are scarcely yet established on a firm basis." I do not feel at all certain that Ortmann's form is that described by Gould, and am even less confident concerning Hoyle's. Actually Gould's type is a very small, probably immature form, and Tryon goes so far as to suggest that it does not differ essentially from *O. mollis*. Ortmann's specimen (measured by the "natural size" figure, *l.c.*, Pl. XXI, fig. 1) is much larger, far narrower, and the web is only one-quarter (25%) of the arm-length. It is otherwise poorly described. Hoyle's specimens are simi-

* In the original the right-hand "cheek" of the ligula is a little narrower.

larly very inadequately described. Hoyle identifies them with Gould's species principally on the strength of possessing large globular eyes, a deep web and smooth surface. The arms in the " Albatross " specimens are subequal, as in the type. However, in Hoyle's specimen No. 7949 (the only one of which the arm-length is given), the longest arm is $\frac{6}{8}\frac{5}{5}$ mm. or 76% of the total length, a figure very different from Gould's (text only).

For the time being it is impossible to accept Ortmann and Hoyle's data as applicable to Gould's species, and at the same time it may be admitted that the status of the latter is still ambiguous. This opinion is evidently shared by Berry (*l.c.*). To judge by his figure (t. xxi, f. 1), it seems very remarkable that Ortmann identified his specimen as referable to Gould's species. Its long thin body is very unlike that of *pusillus*, and suggests that it might have been a form of *O. macropus*. It was very much larger than Gould's specimen and, from the figure (natural size), must have been about 140 mm. over-all.

Octopus (Octopus) arborescens (Hoyle).

Polypus arborescens, Hoyle (1904*b*, p. 189, Pl. II, figs. 8, 9, 12; Pl. III), *id.* (1905, p. 979), *id.* (1907*b*, p. 454), Massy (1916*a*, p. 207), Robson (1921, p. 438, Pl. 66, fig. 3); *Octopus arborescens*, *id.* (1925, p. 104), Winckworth (1926, p. 328).

Syntypes.—In the University Museum, Liverpool.

Specimens examined.—Two specimens (Brit. Mus. ♀♀) from Cargados Atoll, Indian Ocean: 1921.9.14.273, 275.

Distribution.—Cheval Pearl Bank and Periya Paar, Ceylon (Hoyle); Pearl Bank, Ceylon (Massy, Winckworth); Hulule, Male Atoll, Felidu Atoll, in 25 fathoms, Fadifolu Atoll in 23 fathoms, and South Male Atoll in 26 fathoms (Hoyle); Zanzibar, harbour, in 5–10 fathoms (Hoyle); Cargados Atoll in 30 fathoms (Robson). Not recorded from over 30 fathoms.

Description.—All the specimens by which this very peculiar and characteristic species is known are very small and never exceed 12 mm. in mantle-length. The largest of these (Robson, 1921) is obviously sexually mature, and it is likely to be quite definitely a small form even when fully grown.

The mantle is rather oblong, somewhat acuminate apically. The head is about as wide as the body, and the eyes are only slightly prominent. The arms are short and subequal, and attain a maximum length of 73% of the total length. The suckers are very small, and the 8th to the 10th are specially enlarged in the male. The web is very deep (33–50% of the arms), and is deepest in the lateral sectors. The surface bears a number of branched papillae of remarkable structure and unknown function. They are fully described by Hoyle (1904, p. 190). The latter suggested, as a working hypothesis, that they were sensory. Ashworth (in Hoyle, *l.c.*) compares them with the " lateral organs " of Annelids. Herdman, who examined them in the living animal, states that they are " contractile " and that they " kept frequently moving."

The colour of the body is dull ochreous grey marked with annular and irregular figures of dark purple colour. The mantle-aperture is

moderate (B). The funnel is very broad and has a blunt apex. The funnel-organ of the type is unknown, and that of the specimens in the British Museum specimen is damaged. There are 5–6 filaments in each demibranch. The radula has a rhachidian tooth with a simple A_2 seriation. The first lateral has a remarkably deep and triangular base. The second lateral has neither heel nor entocone. The shaft of the third laterals is straight and their bases are small. The hectocotylized arm is practically as long as its fellow in the only male known (Massy). The ligula is very small (2·5% of the arm).

Maximum size.—33 mm. (Robson).

Variation.—There is some variation of the colour of this species. Hoyle (1905) describes one of his Laccadive specimens as deep purplish in colour. The annular markings found in the type specimen are not seen in the specimens from Cargados and Massy's Singhalese example.

Remarks.—It may be ultimately shown that the deep web and peculiar papillae of this species are juvenile characteristics. This, however, is not very likely, and the species is otherwise distinguished from its congeners by the radula, very deep web, and characteristic markings.

Octopus (Octopus) chierchiae, Jatta.

Octopus chierchiae, Jatta (1889, p. 64), *id.* (1899, p. 19, taf. 1, figs. 3–14).

Syntypes.—Not traced.

Distribution.—Panama (Jatta).

Description.—The female has a globular, almost spherical body, the head being much narrower than the body and marked off by clear, ocular constrictions. The male is longer and more slender and the head is wider than the body, the general build being like that of *O. tenebricus*. The arms in the female are in the order 4.3.2.1., and are very short, *i.e.* about 62% (from plate in Jatta (1899)). Both animals are very small, being only 4 cm. in maximum length, and are probably young. The suckers in the male are larger than those of the female, and in that sex are modified on all the arms other than 3R, being reduced to cylindrical tubercles over the distal fifth of each arm. This modification is like that found in *Eledone*, and has only been described in *Octopus* for the female of *O. maorum* by Hutton. The web is extensive, extending up the arm for about a third of the length. It has the form C.D.E.B.A. in Jatta's figure 12. It is prolonged up the arm. The funnel-organ is **W**-shaped. The rhachidian tooth has a symmetrical seriation, possibly of formula A_2 or A_3. Jatta's figures of the other teeth are not very good. There seems to be no entocone on the second lateral. The stylets are like those of *O. vulgaris*. The hectocotylus is very small. Assuming that figure 13 on Pl. I of the full description (1899) shows the whole length of the third right arm, the ligula is about $\frac{1}{12}$th of that arm (8%). The ligula is deeply grooved but smooth. (For the modification of the other arms in the male see above.) The surface seems to be entirely smooth. The colour is very characteristic, and reminds us of certain forms of *O. australis*, as it is marked on the mantle, head and arms with brown stripes, the

stripes being transverse on the body and arms and more or less longitudinal on the head and web. The colouring of the male and female is alike.

Size of the female specimen, 40 mm.

Remarks.—This is a highly characteristic form. The modification of the suckers of all the arms in the male and the colour-pattern are very remarkable. The shortness of the arms is possibly due to the immaturity of the largest specimen.

Octopus (Octopus) parvus, Sasaki.

Polypus parvus, Sasaki (1917, p. 365); *Polypus pavus* (sic !), *id.* (1920, p. 171).

Syntypes.—In the Agricultural College, Sapporo.

Specimen seen.—One (♀) from Shimizuminato : U.S.N.M. 332965.

Distribution.—Satsuma, Shimizuminato (Japan); depth not given.

Description.—(Sasaki, 1917, and No. 332965.) The body is rather globular, somewhat longer than wide; the head is rather narrow (only 53% of the length). The arms are subequal according to Sasaki, but unequal in No. 332965, in which the formula is probably 2.3.4.1. The length of the second arms is 77% of the total length. The total length only of the type specimen is given, and there are no means of calculating its arm-ratio, etc. The suckers are thickly set and conspicuously but not abruptly enlarged in No. 332965, in which the largest are 16% of the mantle-length. The web differs very little in its sections, and is only moderate in depth (20% of the arms). The funnel-organ is thin and **W**-shaped. The surface is uniformly covered with beady warts. The colour is dirty brownish-purple (332965). The gills have 12–9 filaments apiece (4–6 in each demibranch). The vaginae are thick. The ink sac is completely visible from outside the visceral sac. The hectocotylus and penis are not described by Sasaki.

Maximum size.—145 mm.

Remarks.—The type description seems to be founded on rather immature specimens, and is here supplemented by notes on a larger female. It is most unfortunate that Sasaki gave no details of the hectocotylus. The species may ultimately prove to be a form of *Octopus rugosus.*

Octopus (Octopus) alatus (Sasaki).

Polypus alatus (Sasaki, 1920, p. 180, Pl. 24, fig. 4).

Holotype.—In U.S.N.M., Washington.

Distribution.—Bongo Suido (Japan), in 437 fathoms.

Description.—The form of the mantle is not described, except for the statement that it is broadest posteriorly and " compact " (? bursiform). It is bordered by a peripheral keel, probably of adventitious nature. The arms are very unequal and have the formula 1.2.3.4., the longest being about 80% (77 or 82, cf. Sasaki, text-figs.) of the total length. The suckers are small, the largest having a diameter of 5 mm. Sasaki

only gives the *ventral* mantle-length, so that we cannot apply our usual criterion of size except to suggest that the largest sucker must be about 7–8% of the dorsal length. The web is on an average 23% of the arms, and is continued up the ventral edge of the latter as a broad membrane. The surface is quite smooth. The mantle-aperture is rather narrow (? B). The funnel is slender and well defined (? with a long, free portion). The funnel-organ is small and W-shaped. There are 11 filaments in each demibranch.

The hectocotylized arm is three-quarters the length of its fellow. The ligula is thick, short and conical; it is 5% of the arm in length. The penis is fusiform in shape, and seems to have a slender appendix which is longer than the terminal part.

Maximum length.—440 mm.

Remarks.—Sasaki does not say if the peripheral keel occurs in both his specimens. If it does, the likelihood is increased that it is a permanent feature of the species. The long appendix resembles that found in *Joubinia*, but it is not possible to decide if this species should be included in that subgenus.

Octopus (Octopus) validus (Sasaki).

(Text-fig. 55.)

Polypus validus, Sasaki (1920, p. 183, Pl. 24, fig. 3).

Holotype.—In U.S.N.M., Washington.

Distribution.—Koshiki Id., Satsuma (Japan), in 424 fathoms.

Description.—The body is a little broader than long, and has a deep median groove. The head is a little narrower than the body, and has a weak nuchal constriction. The arms are subequal and in the order 1.2.3.4., the longest being a little more than 66% of the total length, and thus very short for an adult animal. The suckers seem to be conspicuously enlarged. The web is uniform and extends up the arms to the extremities. It is about 25% of the arm-length. The surface is covered in the main dorsal area with conspicuous stellate or rosette-like warts well defined from the general surface (? like that of *O. pallida*). The transition between the dorsal and smooth ventral areas is somewhat abrupt.

Fig. 55.—*Octopus validus*. Hectocotylus. (After Sasaki.)

The mantle-aperture is moderate (? B). The gill-filaments number 15 in each gill (sc. 7–8 in each demibranch). The hectocotylized arm is much thicker and shorter than its fellow. The ligula is short, thick, a little flattened dorso-ventrally, and has a blunt extremity. The copulatory groove is smooth and wide. The penis is cylindrical.

Maximum size.—184 mm.

Remarks.—The single specimen representing this species was obtained at a considerable depth. Its squat form, short arms, and reduced number of gill-filaments suggest that it may be a Bathypolypoid form. Sasaki mentions neither the ink sac nor the funnel-organ, so that we get no definite clue to its real position.

Octopus (Octopus) spinosus (Sasaki).

Polypus spinosus, Sasaki (1920, p. 177, Pl. 24, fig. 1).

Holotype.—In U.S.N.M., Washington.

Specimen seen.—One (♀) from " Between Sado Islands and Hako date "; U.S.N.M. 332968.

Distribution.—Tsugaru Straits, Japan, in 44–207 fathoms.

Description.—The form of the mantle is not indicated. The head is slightly narrower than the body. The arms are subequal and very short (64% of the total length). The suckers are small, not exceeding 7% of the mantle-length. The web is very well developed, its deepest sector being 32% of the longest arm. Its shape is not indicated. The surface is covered thickly with large spinous warts with stellate bases, and there is a single " low warted " cirrhus over each eye. The mantle-aperture is distinctly narrow (B). The funnel is rather short and its organ is **W**-shaped, the middle part being " a little longer " than the outer limbs (but cf. fig.). The filaments in each gill are 21–22 (sc. $10\frac{1}{2}$–11 in each demibranch). The ink sac is present. The small size, short arms and deep web suggest that this is a juvenile form. The sculpture, however, from the description seems to be very characteristic. The " stellate base " of the warts (Sasaki) suggests the *pallida* type of sculpture or even that which is sometimes seen in *rugosus*. The suckers are, however, very small and could hardly justify the reference of the species to either of the above-mentioned forms.

Variation.—The mantle of specimen 332968 is globular, its breadth being 84% of its length. The head is somewhat narrower than the body. The arms are scarcely subequal as Sasaki states, as No. 1 (L) = 42 mm. and No. 2 = 52 mm. The longest arms are 73%. The suckers are small, 7–9% of the mantle. The web is subequal, and about 42% of the arms in length. The sculpture is very worn. It consists of large and small circular (but sometimes irregular) warts. I do not see any very clear indication of the " stellate bases " described by Sasaki. The colour is dingy ochreous, mottled and reticulated dorsally with purple.

Maximum size.—85 mm.

Remarks.—I think the specimens representing this species are both young. It is not easy to decide if they are juvenile forms of any known species. It is possible that they may be forms of *rugosus*, though I think *rugosus* of an equivalent size has longer arms and it certainly has a shallower web.

Octopus (Octopus) ochotensis (Sasaki).

Polypus ochotensis, Sasaki (1920, p. 174).

Holotype.—In U.S.N.M., Washington.

Distribution.—Cape Patience, Sea of Okhotek, in 75 fathoms; Taraika Bay, Sakhalin, in 119 fathoms.

Description.—The mantle is globular as broad as long; the head is large, the " neck " is " not marked." There is a peripheral ridge around the mantle-sac (see p. 7). The mantle-aperture is moderate (? B).

The arms are subequal and short, about 74% or a little more of the total length. The web is deep, being 33–25% of the arm-length. It is continued up the arm as a narrow membrane. Its shape is not described. The suckers are not specially enlarged. The surface is soft and loose, and is either smooth or bears a few warts. There are three cirrhi over each eye.

The funnel is incorporated in the head, except for a short portion at the extremity. The outer limbs of the funnel-organ are rather less than half the length of the inner limbs, as in *O. medoria* and *O. tenuipolvinus*, an unusual form of organ. There are 9–9½ filaments in each demibranch. The ink sac is present. The ligula of the hectocotylus is small (4%). The vaginae are very thick and short. The ovarial eggs are large, viz. about 9 mm. long. The penis is spindle-shaped "the swollen middle part connected with Needham's organ" (Sasaki), which is a very unusual form for this organ to assume.

Maximum length.—190 mm.

Remarks.—The large size of the eggs, the squat body and short arms, suggest that this species is related to *Paroctopus*. The hectocotylus is, however, very short.

Octopus (Octopus) inconspicuus, Brock.

Octopus inconspicuus, Brock (1887, p. 603, Pl. XVI, fig. 4), Joubin (1894, p. 33), Appellöf (1898, p. 564).

Holotype.—In the University Museum, Göttingen.

Distribution.—Amboina (Brock, Joubin); Ternate (Appellöf).

Description.—It is not easy to be certain that Joubin and Appellöf had examples of Brock's species before them. The former does not describe the sculpture of his species (a very important feature). The latter gives no measurements, confining his remarks to the sculpture. Both authors speak with some confidence as to the similarity between their specimens and those of Brock, though Appellöf is evidently aware of some considerable amount of variation. The mantle is oval and gently rounded posteriorly. The eyes are rather large and prominent. The head is narrower than the body, and there is no "neck." The mantle-aperture is very wide (C). The arms are laterally flattened. The second arm is rather conspicuously longer than the rest, and attains 75–78% of the total length. The suckers are very low and closely placed. They are conspicuously enlarged at the 12–20th pair (Brock), or only the 9th on the hectocotylized arm (Joubin) is so enlarged. The web is uniform in all its sectors and very poorly developed, being only 13–10% of the longest arm. The lateral membranes are very peculiar. It is very curious that neither Joubin nor Appellöf commented on the remarkable condition described by Brock in the following words :— "Schwimmhäute sind *im unteren Drittel* der Arme (mit Ausnahme des hectocotylisierten naturlich) nicht vorhanden, im zweiten Drittel der längeren Arme aber ganz gut entwickelt und von da an allmählich abnehmend bis zur Spitze zu verfolgen." Now unless Brock's specimen was very much mangled and distorted, and unless he made a very careless and superficial study (it should always be borne in mind that the arm-membranes some-

times become folded and adherent to the arms), it seems to me that he is describing a very unique arrangement of the web which would necessitate the creation of a separate subgenus at least for this form. The only parallel I can find to this arrangement is in *Ocythoë* (cf. Naef, 1923, p. 753, fig. 449). In that form, however, the membrane is present at the base, though it begins by being very feeble and rapidly becomes larger. It is a very great pity that Joubin and Appellöf did not pay any attention to this very remarkable feature. The hectocotylus is of normal appearance. I do not understand why Brock calls it " mässig gross," as it measures only 4 mm. on an arm 200 mm. in length; in Joubin's specimen it is only 4·3% of the arm. The skin of the ventral surface is smooth. That of the dorsal area is very much wrinkled and bears well-marked flat, broad warts, sparsely scattered in the type, more numerous in Appellöf's specimen. On the first and second arms and on the mantle are found some characteristic cirrhi (or large warts), which are conical and contain a marked depression at the tip. There are six of these symmetrically arranged on the back, and there are also four in a transverse row. Each eye has three ocular cirrhi. The importance of this sculpture is discussed by Brock. The colour is a clear yellowish-brown, which on the back and sides is marbled with dark slate grey.

Total length.—280 mm.

Remarks.—Brock compares this form with the " *O. fontanianus*-group " on the quite inadequate grounds of the enlarged suckers. Appellöf thinks it may be identical with *O. tenebricus*, Smith. A glance at pp. 42 and 50 will, however, dispose of this suggestion. As already said, I think that in all probability this may prove to be a representative of a new subgenus.

Octopus (Octopus) salutii, Vérany.

Octopus Salutii, Vérany (1839, p. 93, Pl. III); *Octopus Saluzzi*, *id.* (1840, plate, fig. 5, ? p. 235); *Octopus Salutii*, Orbigny (1840, pp. 27, 33, = *O. vulgaris* in error), Gray (1849, p. 6, = *O. vulgaris*, in error), Vérany (1851, p. 20, Pl. 9); *Octopus salutii* (?), Targioni Tozetti (1869A, p. 18, *fide* Naef, 1923); *Octopus salutii*, Hoyle (1886, pp. 7, 216); *Octopus Salutii*, Carus (1890, p. 459); *Octopus Salutii* Fra Piero (1895, p. 270); *Octopus salutii*, Jatta (1896, p. 224, Pls. 4, 21, 22); *Polypus Salutii*, Naef (1916, p. 16); *Octopus saluzzii*, Naef (1923, p. 699, monograph); *Octopus salutii*, Robson (1925, p. 105, radula).

Holotype.—? Musée d'Histoire Naturelle, Nice.

Specimens examined.

(*a*) In Brit. Mus.

One (♀) from Naples; 98.5.21.347. One (♀) from Nice; 89.2.11.7.

(*b*) M.H.N., Paris.

One (♂) from Nice.

Distribution.—This form is apparently confined to the Mediterranean. It is recorded from Nice, Genoa and Naples. There are no records of its occurrence in the Adriatic or E. Mediterranean. The depth at which this species habitually lives is uncertain. Jatta (*l.c.*) says " oltre i cento metri," and it is apparently found off Naples in deep water and may be

common at such depths. It is not recorded, however, in Lo Bianco's report (1903) of the deep-water fauna of the Mediterranean. The species is apparently very rare. Vérany only saw one specimen (1851, p. 22), and Jatta (*l.c.*, p. 227) says it is very rare at Naples.

Description.—(*a*) The body in the living animal is not unlike that of *O. vulgaris*, being short and broadly oval. The head is rather narrower than the body. The arms usually do not differ very much in their length, which is about 75% of the total length. The pallial aperture is wide (B–C). The web has the formula C = B = D.A.E., but see Naef, *l.c.* It is moderately deep (about 24% of the arm-length), rather evenly developed, and is notable on account of the wide membranes by which it is carried up the sides of the arms. The suckers attain a maximum diameter of 5% of the mantle-length in the female. Naef (*l.c.*, p. 700) says that in the male some of the suckers are strikingly enlarged. The funnel is free for about $\frac{7}{10}$ of its length in one of our specimens and is broad and stout. The funnel-organ is W- or W-shaped. The gills have 9–10 filaments in each demibranch. The radula has been figured by Jatta (*l.c.*, t. 21, fig. 8) and Robson (1926, fig. 16). A preparation made from one of our specimens (Robson, fig. *cit.*) is more or less identical with that figured by Jatta. The latter, however, represents the first lateral as narrower and devoid of the upturned inner angle seen in our specimen. This may be due to difference of mounting. The radula on the whole is like that of *O. vulgaris*; but in the second lateral the mesocone is nearer the inner end, and the heel is scarcely prominent. *Reproductive organs.* The hectocotylus is figured by Jatta (*l.c.*) and Naef (*l.c.*). It is very long and differs radically from that of the other Mediterranean forms, recalling that of *Octopus hongkongensis* and *O. gilbertianus* in size and shape, if not in detail. That of *O. macropus* is obviously a link between the small ligula of *vulgaris* and that of *salutii*. The male internal genitalia are unknown. The oviduct opens a few millimetres above the edge of the septum. Its distal part is 33% of the mantle-length. In the single animal dissected the oviduct gland was large, circular and dark in colour.

The surface is covered with irregular warts.

The tissues of the mantle tend to be gelatinous. In life the animal is an orange-yellow colour. I have not seen enough preserved specimens to justify any verdict as to the colour they tend to assume.

Maximum size.—290 mm. (Jatta, [length of mantle, head and arms: not erroneous total as given]).

Variation.—In the small number of specimens seen the most marked variation is in the body-shape, which is either as described above (apparently the usual form) or narrower and more distinctly ovoid. Naef (*l.c.*) gives no data as to variation; though he mentions that the borders of the ligula are sometimes widely parted.

Habits.—Unknown. As stated above this species is probably a deep-water form.

Remarks.—The identity and nomenclature of this species has been subject to very little discussion. Orbigny and Gray both held that it is identical with *O. vulgaris*; but of recent years no author has paid serious attention to that opinion, which is, on examination, entirely erroneous. *O. salutii* differs from *O. vulgaris* in (1) its exceedingly long ligula;

(2) its subequal arms; (3) the evenly-developed web with wide extensions; (4) the form of the second lateral tooth, and (5) probably its habitat. The form of the web, arm-formula and colour distinguish it at once from *O. macropus*. Naef (*l.c.*, p. 702) thinks its appearance recalls that of half-grown examples of *O. vulgaris*. The wide fleshy arm-membranes are not unlike those found in *Velodona*. On account of the size of the hectocotylus, the short subequal arms and subequal web it is to be regarded as more akin to the N. Pacific forms, and I tentatively suggest that it may belong to the *leioderma*-like group, though the arm and web formula are not typical.

Octopus (Octopus) madokai (Berry).

Polypus pustulosus, Sasaki (1920, p. 176, Pl. 23, fig. 5, preocc. (Blainville, 1826, p. 186)); *Polypus madokai*, Berry (1921, p. 353).

Holotype.—In U.S.N.M., Washington.

Distribution.—Sagami Sea, E. Japan, in 70 fathoms.

Description.—The body is as wide as it is long, with a narrow mantle-aperture (? B), the head being a little narrower than the body. The arms are unequal; Sasaki gives as the formula 1.2.3.4. = 4, the significance of the last relationship being obscure. The first arm is about 75% of the total length. The suckers are large, but there is no discontinuous enlargement. The web is moderate in depth, its index being 25%. The surface is sparsely covered with minute warts, and there are about twenty larger tubercles regularly arranged and two ocular cirrhi over each eye. The colour is uniformly drab (in formalin).

The funnel-organ is roughly W-shaped, the limbs of the median part being each wider than the lateral limbs. The anteriorly directed extremities are rounded, the posterior ones acuminate. Each gill has 21 filaments ($10\frac{1}{2}$ in each demibranch).

There is a large ink sac, the proximal part of which is sunk deeply into the liver. The vaginae are slender.

Maximum length.—380 mm.

Remarks.—Berry (*l.c.*) points out that the name *pustulosus* was used a century earlier by de Blainville (*l.c.*) for an Australian Octopod.

Octopus (Octopus) hawaiiensis, Eydoux & Souleyet.

Octopus hawiiensis [sic], Eydoux & Souleyet (1852, p. 9, Pl. 1, figs. 1–5); *Octopus hawaiiensis*, Tryon (1879, p. 118, ? = *punctatus*), Ortmann (1891, p. 672, ? = *marmoratus*); *Polypus hawaiiensis*, Berry (1909, p. 418), *id.* (1914*a*, p. 290).

Holotype.—Not traced.

Distribution.—Only known from Hawaii.

Description.—The body is globular or globular-elongate. The head is clearly marked off by preocular and postocular constrictions. The eyes are large and prominent. The arms are in the order 2.1 = 3 = 4, and are 76% of the total length. The web (from the figure) is more or less subequal (? C.B.D = A.E), and is about 20% of the arms in length.

The surface is smooth and is of a bluish-grey colour covered with minute dark chromatophores, the colour as usual being lighter below.

Maximum size.—130 mm.

Remarks.—There is no information concerning this species other than the scanty original description reproduced in its essentials above. Since its description it has not been recorded again. Berry (1914), who made a careful study of the Hawaiian fauna could associate it with no known species. The suggestions of Tryon (that it is referable to "*punctatus*") and of Ortmann (that it is the same as *O. marmoratus*) are devoid of value. The globular body, smooth and non-cirrhous surface, large head, short arms and the arm-formula serve to distinguish it from other Oriental and Pacific forms. The type was, however, a small specimen with a mantle-length of 20 mm., and it may well be the young of some described species.

Octopus (Octopus) saphenia, Gray.

Octopus saphenia, Gray (1849, p. 11), Hoyle (1889, p. 221, as "insufficiently characterized").

The type of this species from the "East Coast of South America" is missing from the British Museum Collection, and was "not found on 26.2.74" (E. A. Smith, MS.). No other specimens are known. Gray's description is as follows :—"Body and arms minutely granular, ocular beards none. Arms moderate; comparative length 2, 3, 4, 1; three upper pairs subequal. Web short, granular above. Cups subequal." The description of the web suggests *O. rugosus*; though, if properly preserved, the three upper arms are not subequal in that species. Gray gives the locality as "Pacific Ocean," but his specimens were obtained from the East Coast of South America.

The available description is too defective for us to discuss the species more fully.

Octopus (Octopus) bermudensis, Hoyle.

O. bermudensis, Hoyle (1885, p. 228), *id.* (1886, p. 94, Pl. II, fig. 5).

Holotype.—In Brit. Mus.

Specimens examined.—In Brit. Mus.

One specimen (♀) from the Bermudas : 1889.4.24.38.

Distribution.—Only recorded from the type locality (Bermuda).

Description.—The body is "spheroidal, acuminate behind." The head is much (?) narrower than the body. Hoyle's statement that the eyes are scarcely at all prominent is somewhat belied by the marked subocular constriction. The arms are in the order 1.2.3.4., and are relatively long, being 86% of the total length. The suckers are small and prominent. The web has the formula ? B.C = D = E. It is very shallow, viz. 14% of the arms, and its sections are subequal. The surface is smooth and there is a small wart over each eye. The colour is "yellow ochre with a pale sienna patch on the back (as in *O. venustus*, Rang) and one on its head."

Maximum size.—58 mm. (mantle-length).

Remarks.—I think the only available example of this species is undoubtedly juvenile. Its size, delicate structure, the coloration and

the low, even and thin web all support this conclusion. Nevertheless, the arms are remarkably long for a young specimen and highly differentiated in length, a most unusual feature. Hoyle (*l.c.*, p. 95) compares it to *O. pusillus*, Gould, and *aranea*, Orbigny. But Heilprin's suggestion (see p. 107) that it may be the young of his *O. chromatus* seems more pertinent. If this is substantiated, my suggestion that the latter is nearly allied to or even conspecific with *O. macropus* ceases to have any value, as in equivalent young stages of *macropus* the arms are more or less subequal.

Octopus (Octopus) joubini, n. sp.

(Plate 6, fig. 1; text-figs. 56–58.)

" *Octopus tehuelchus*, D'Orb.," Hoyle (1886, p. 89 (in error)).

Holotype.—In Brit. Mus.

Specimen seen.—In Brit. Mus.

One specimen (♀) from St. Thomas, Danish W. Indies, in 8 fathoms : 89.4.24.30.

Distribution.—Only known from the type locality, St. Thomas, W. Indies.

Description.—The specimen measures 16 mm. in body-length, but it is sexually mature, the ovary being full of ripe eggs. The distended ovary may cause the visceral sac to be a little wider than in the male and non-gravid females.

Fig. 56.—*Octopus joubini*. × 1·7.

The eyes are staring and very prominent. The visceral sac is relatively longer than in Orbigny's species, and the proportions of sac and web are markedly different. The arms seem to have the formula $3 = 2.4.1.$, not $4.3 = 1.2$ as in *tehuelchus*. They are 67–69% of the total length, whereas in the latter they are 80%. The web is, as in *tehuelchus*, equal all round, but it is 33–30% of the arm-length, not 20–25% (?). The pallial aperture is of type B–C. The suckers are 6% of the mantle-length, which, if we may judge by Orbigny's figure in which the suckers are about 12%, constitutes another difference from *tehuelchus*. The gills, septum and reproductive organs are very much obscured by the large ovary and cannot be described. The mantle, web and arms are completely smooth. The coloration has been spoilt by preservation.

The funnel (which may have been damaged) is wide and broad. It is free for about ⅔ of its length. The funnel-organ appears to be thick and heavy and the inner limbs of the W are closely opposed (cf. fig. 57).

The *radula* (fig. 58) is very remarkable and quite unlike that of any species with which I am familiar. The preservation is not very good, and I am unable to speak with certainty about the early teeth. There is a simple A 4–5 seriation in the later teeth, but the ectocones are very low and obscure. The first lateral is almost degenerate. The second

lateral has a remarkably low cusp and no entocone. The third lateral is strongly curved and sickle-shaped.

Maximum size.—50 mm. (Brit. Mus.).

Remarks.—Hoyle in listing this form was evidently uncertain as to its status. From a careful comparison of Orbigny's description of *tehuelchus* and Hoyle's original specimen, I cannot but conclude that they have nothing at all in common, and that, as the latter cannot be satisfactorily assigned to any of the known Atlantic species, it should be given a new specific name. Beyond the equality of the sections of the

Fig. 57.—*Octopus joubini.* Funnel-organ.

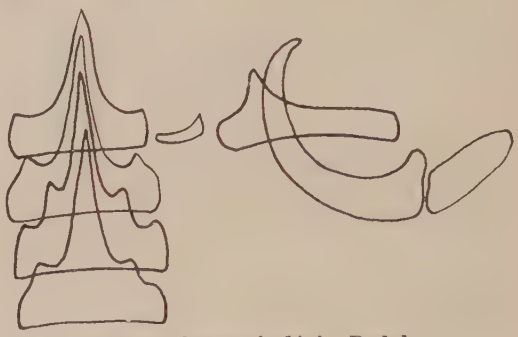


Fig. 58.—*Octopus joubini.* Radula.

web and the absence of extensions up the arms, which may suggest affinity with *Joubinia*, there is nothing to suggest that this is not referable to *Octopus* (s.s.).

Octopus (Octopus) verrilli, Hoyle.

Octopus pictus, Verrill (1883, p. 112, Pl. III, fig. 3 (preocc. (de Blainville, 1828, p. 8)); *Octopus verrilli,* Hoyle (1886, p. 93).

Syntypes.— ? In U.S.N.M., Washington.

Distribution.—Flannegan Passage, etc., Barbadoes, in 27 and 69 fathoms.

Description.—The body is more or less quadrate in outline, the head being slightly broader than the body. The eyes are scarcely prominent and the head is not marked off by a neck. The arms are subequal and about 66% of the total length. The sections of the web are probably of equal depth, except in the ventral section where it is shallower.* It is about 25% of the arms in depth. The suckers are relatively large. The surface is entirely smooth except for a single, small, rounded wart over each eye. The entire surface is covered with rather large round, reddish-brown or dark-brown spots "usually with a darker central point." "Between them there are numerous minute lighter-coloured chromatophores. The inner surfaces of the web and arms yellowish-white."

Total length.—About 24 mm. (Verrill).

Remarks.—Verrill says that the types of this species are probably the young of some larger species, but that it is unlike any of the described

* But cf. Verrill, *l.c.*, Pl. III, f. 3.

West Indian forms known to him " in its peculiar ocellated coloration and the very smooth surface of its body, with only a single wart above the eye." The specimens are undoubtedly young; but since the first description no fresh data have been obtained as to the adult form to which they belong. It may be referable to *O. rugosus*.

Hoyle pointed out (*l.c.*) that the name originally given by Verrill is preoccupied by Brock's Australian "*pictus*" (1882). The latter, however, was not the first usage, the name having been employed by de Blainville for an *Octopus* (1828, p. 8).

Octopus (Octopus verrilli), Hoyle, var. **palliata,** n. var.

(Text-fig. 59.)

Holotype.—In Brit. Mus.

Specimens seen.—In Brit. Mus.

One specimen (sc. ♀) from Harbour Island, Bahamas : 1908.1.30.5. (Type.)

Distribution.—Only known from the type locality, Harbour Island, Bahamas.

Description.—The following is a tabular comparison of the variety and parent form :—

Fig. 59.—*Octopus verrilli*, var. *palliata*. × 2·7.

	verrilli.	Var. *palliata*.
1. Length of head and body .	8 mm.	11 mm.
2. Mantle-width % length .	100% (from fig.)	90
3. Interocular	100%	90
4. Arms, order . . .	Subequal.	Subequal.
5. Arms, maximum length % total length . . .	66	56
6. Web, order . . .	? A = B = C = D.E.	The same.
7. Web, depth % arm . .	25%	42%
8. Suckers	Two basal suckers small, rest relatively large.	The same.
9. Colour	The entire surface covered with reddish-brown spots, with chromatophores between.	Dark spots on dorsum of arms only. Chromatophores over all surface except on ventral surface of web.
10. Total length . . .	24 mm.	29

Remarks.—I refer the young specimen here described to Verrill's species with some hesitation. There is, however, enough likeness between the two forms to render it probable that they are best treated as conspecific. It must be remembered that Verrill's types themselves were juvenile forms.

Octopus (Octopus), sp.

Octopus brevipes, Orbigny (Hoyle, 1886, p. 101).

Specimens seen.—In Brit. Mus.

One juvenile specimen (? ♀) from the N.W. Pacific, 24° N. 138° E. (South of Japan); at surface.

Distribution.—Only recorded from the above locality.

Description.—The mantle is squat and rounded, not oval as in *brevipes.* The eyes are deeply sunk and not nearly as prominent as in the latter. The arms are subequal, and as in Orbigny's species they are very attenuated at the tips. They are longer, however (the two animals are of the same mantle-length), being 48% of the total length instead of 35%. The oral suckers are very large, diminishing towards the tips with a sudden drop in size at the apical sixth of the arm. The web is far deeper than in *brevipes,* being about 50% of the arms instead of being very shallow. The funnel again is very short and barely elevated, whereas that of *brevipes* is long. There are ten branchial filaments on the outer demibranch. The specimen seems rather discoloured. There are only the faintest traces of patches of colour on the mantle, whereas in *brevipes* it is plentifully adorned with large blotches. The arms, on the other hand, seem clearly to have had a strong pattern of large dark red spots, larger in size than those of *brevipes.*

Maximum size.—11 mm. (Hoyle).

Remarks.—This immature specimen was assigned by Hoyle to Orbigny's species from the Atlantic; but it unquestionably does not belong to it, if indeed *brevipes* is not actually an early stage of another species.

Octopus (Octopus), sp.

Specimen seen.—In Brit. Mus.

One specimen (♀) from St. Vincent's, Cape Verde Islands (Coppinger): 79.10.15.240.

Description.—This small and distorted specimen has the following characteristics:—(1) mantle-length, 15 mm.; (2) width index, 53%; (3) interocular index, 60%: (4) arms, 2.3.4.1.; index, 70%; (5) web = type of *defilippi.*

The general facies with very prominent eyes is suggestive of our *defilippi* var. *dama.* The arms, however, are very short, and, for what it is worth, their order is not like that of *defilippi.*

Octopus (Octopus), sp.

Specimen seen.—In Brit. Mus.

One specimen (♀) from the Azores (Rothschild): 1903.10.8.48.

Description.—This interesting form is in a very mangled and distorted condition, and I am unwilling to describe it as a new species on such unsatisfactory material.

In general it seems to be like Howell's W. Indian *filosus*. The arms have filiform extremities, the proportions of the head resemble those of *filosus*, and the mantle (width index 60) and arm-length (index 82%) agree tolerably well with those of *filosus*. There are a number of ocular "beards," and the eyes and funnel are very prominent. Nevertheless, the relation between the normal and filiform part of the arm is not like that of *filosus*; nor, as far as I can ascertain, are the suckers single over the thin part. Again, the proportions of the web are remarkable. Howell (Pl. 14) does not figure the whole web, but that part of the latter which is visible is not at all like our specimens. In the latter there is a very remarkable disparity in web-level between A and E as opposed to D. A is $\frac{1}{8}$ of the arm-length, E is $\frac{1}{7}$, C is $\frac{1}{4}$ and D is $\frac{1}{3}$–$\frac{1}{4}$. This represents the maximum disparity in web-level recorded. The surface of the mantle, which has suffered from bad preservation, seems to have been covered with low warts of the *vulgaris* type.

Octopus (Octopus) superciliosus, Quoy & Gaimard.

Octopus superciliosus ("Poulpe de Western"), Quoy & Gaimard (1832, p. 88, Pl. 6, fig. 4), Orbigny (1840, p. 41, Pl. X, fig. 3); *Octopus westerniensis*, *id.* (*l.c.*, Pl. 23, fig. 9).

Holotype.—In M.H.N., Paris (?).

Specimen seen.—One (♂) in M.H.N., Paris. (? Type.)

Distribution.—Only known from the type locality, Port Western, Bass, Straits.

Description.—The body is oval, posteriorly acuminate. The head is well marked, but distinctly narrower than the body, and the eyes are prominent. The arms are in the order 2.4.3.1., and are about 77% of the total length. The suckers are large and widely spaced. The web is about 19% of the arms in length, and its various sectors are equal in depth, E being very slightly shallower than the others. The funnel extends half-way towards the edge of the web. The funnel-organ is obliterated in the specimen assumed to be the type. The surface is more or less finely granular and decorated in addition by a small number of prominent warts or cirrhi. Those seen in the presumptive type are not so prominent as in the original figure. The colour seems to have been white (Q. and G.).

Total length.—100 mm. (Orbigny), "trois pouces six lignes" [sc. 87 mm.], Quoy & Gaimard.

Remarks.—Orbigny's description of this species was founded upon an examination of the type (?) specimen brought back by Quoy and Gaimard. A specimen designated as the type in the Natural History Museum, Paris, agrees fairly well with the original description, figure and measurements. I do not think any other described species can very well be mistaken for this form. But the type specimen is obviously young (16 mm. mantle-length, *fide* Orbigny) and not in a very good condition, so that it may turn out to be the young of some described species.

Octopus (Octopus) wolfi (Wülker) (? juv.).

Polypus wolfi, Wülker (1913, p. 458, Pl. 22, fig. 3*a*, *b*).

Holotype.—In S.B.I., Frankfurt a/M.

Specimen examined.—One ♂ (juv.) in Senck. Mus., Frankfurt a/M. (Type.)

Distribution.—Popeete (? Papeete), Tahiti (only known from the type locality).

Description.—The mantle is conical, the base of the cone being the line between the eyes. The greatest width of the body is markedly exceeded by its interocular width. The arms are very short (66%) and subequal, and the suckers form a peribuccal ring. The web is subequal, but the lateral area (C) is a little deeper than the terminal, and A is slightly deeper than E. The web is moderate in depth (15%). The hectocotylus is very well developed, as is the sperm groove. The ligula is about 10% of the arm, and seems to be well formed. The funnel is broadly conical. The surface bears numerous separate "einzeln stehende" reddish papillae, of which some are larger than the rest. The colour is dark wine-red with a feeble tendency to become (? locally) violet.

Maximum size.—32 mm.

Remarks.—The only available specimen of this form is undoubtedly juvenile. I think the small size (about 13 mm. dorsal mantle-length) and very short arms and web indicate that it is not yet fully grown. Nevertheless, the hectocotylus and sperm groove are well developed. Whether the testis is likewise mature it is impossible to say. It is undoubtedly very interesting to find the hectocotylus, etc., completely differentiated in so small and (?) young an animal. Very unfortunately we cannot discuss the question effectively, as (*a*) the actual age and (*b*) the condition of the testis are unknown. In the meantime I am not certain that Wülker makes sufficient allowance for the way in which all the characters (short arms, broad head, etc.), on which he relies in order to separate this form from all other Indo-Pacific species, are affected by age. Even the remarkable width of the head might be reduced with advancing age. I can only accept this as a distinct species with very great reservation. The sculpture looks as though it might in the adult state be like that of *O. rugosus*.

Octopus (Octopus) gardineri (Hoyle).

Polypus gardineri, Hoyle (1905, p. 976, figs. 144–5), Robson (1921, p. 438, fig. 4); *Octopus gardineri*, Robson (1925, p. 105), Winckworth (1926, p. 327).

Syntypes.—In the University Museum, Cambridge.

Specimens examined.—Two specimens (Brit. Mus. ♂♂) from Coetivy Island, Indian Ocean: 1921.9.14.272.

Distribution.—Hulule, Male Atoll (syntypes); Minikoi, Maldive–Laccadive Islands, in boulder zone (Hoyle); Coetivy Island (Robson), in 32 fathoms; Ceylon (Winckworth); Rotuma, Fiji (Hoyle).

Description.—The body is described as pear-shaped, but in the original figure (fig. 145, p. 976) of the animal it appears as subglobose and bursiform. Owing to the great size of the eyes the width of the head exceeds that of the mantle by a good deal, there being a well-marked "neck." The arms are subequal and 72–75% of the total length (from his table of dimensions Hoyle is clearly in error when he says the arms are "about four times as long as the body"). Winckworth gives a greater arm length than is found in either the type or Robson's specimen. The suckers are very much enlarged at the third pair, two being especially wide. The sectors of the web are subequal in depth, about 25–35% of the arms in length and devoid of extensions. The surface is smooth except in Hoyle's specimen 978, which has a few rudimentary papillae on the back. Small ocular papillae are usually present. The colour is a dull yellowish-grey plentifully sprinkled with small purplish chromatophores. The mantle-aperture is rather narrow (B). The hectocotylized arm is more or less the same length as its fellow of the opposite side, the ligula being "of the type seen in *P. vulgaris*" (Hoyle). Those of the Museum specimens are not in good enough condition to describe. The radula has a rhachidian tooth with a symmetrical A3 seriation. The second lateral has a very long base, small mesocone and no entocone. The third laterals are rather slender. These specimens are unfortunately not in good enough condition to dissect.

Maximum size.—50 mm. (Hoyle).

Remarks.—Hoyle surmises that this undoubtedly juvenile form may be the young of *O. fontanianus* or *O. tonganus*. The conviction has been expressed elsewhere (p. 189) that *O. fontanianus* does not pass into the Indian Ocean. There is really no likeness at all between *O. gardineri* and the two forms suggested by Hoyle. The very remarkable shape of the head and body, the subequal arms and web (possibly still influenced by immaturity), absence of arm-membranes, the radula and suckers are a very distinctive combination of characters. Winckworth and Robson's diagnoses appear to be correct. I am a little inclined to be sceptical concerning Hoyle's specimen from Rotuma (near Fiji). Seeing that *gardineri* is, as far as we know, a distinctive species, it was an astonishing coincidence that in two sets of material concurrently studied Hoyle should have obtained representatives of the same new species from two places as remote from each other as the Maldives and Rotuma!

Subgenus ii. **Macrotritopus,** Grimpe, 1922.

Pelagic Octopodinae with the third arms very much longer than the remaining arms.

Type of the subgenus. Octopus equivocus (new name for *O. gracilis*, Verrill (preocc.)).

This subgenus was proposed (as a genus) by Grimpe without description, but with Verrill's "*gracilis*" (1884) designated as the type. If it is to be maintained it should also contain Berry's *Octopus scorpio* (1920), Hoyle's *O. bandensis* (1886) and the newly described species *O. kempi*. I propose to retain it merely as a temporary expedient. With one exception all the forms entitled by their resemblance to Verrill's "*O.*

gracilis" to inclusion in the group are represented by very small and, in all likelihood, juvenile specimens. Verrill states of "*gracilis*" that it "is probably young of a species which grows to a larger size." Berry does not express an opinion concerning the age of his *O. scorpio*, but from his figure and description I think that it probably is not adult. The reasons for regarding these forms as immature are as follows: (1) They are all very small, under 12 mm. in mantle-length.* (2) The web is subequal in all its divisions, and in *bandensis* and *kempi* fragile and transparent. (3) The coloration is that usually found in immature specimens. (4) The tissues of those I have examined are delicate. (5) The radula of *kempi* (which otherwise agrees with the rest of the species) is very fragile and the mandibles are very imperfectly chitinized. But although they are all young, they cannot be assigned to any species previously described. Degner (1925, p. 79) has referred to *Scaeurgus* some young Octopods with large third arms and traces of hectocotylization on the left side. As I have no male specimens of *Macrotritopus* with signs of the hectocotylus, and as none have been described, it is impossible to say if any of the forms previously described should also be placed in *Scaeurgus*. We must either conclude that they are young forms of species hitherto undescribed or that they undergo some kind of metamorphosis in the course of subsequent development, as a result of which they may assume the adult form of some described species. On the other hand, the enlargement of the third arms is plainly not an exclusively juvenile character. If Appellöf's diagnosis is correct, his specimen of *bandensis* from Ternate is a large specimen (45 mm. from apex to top of web in sector A), and its third arm is conspicuously enlarged. It follows that for the time being we have no option but to treat these forms as representatives of a distinct group pending an increase of our knowledge of the growth-changes. I do not, however, think that even if they are ultimately traced to some undescribed adult form which resembles them in their more striking characteristics, they can be given the status of a separate genus. If we exclude the equal web and the highly characteristic coloration, which are juvenile features, the only character in which they depart from the normal *Octopus* is the great size attained by the third arms. This is indeed striking, but it is not enough, in itself and unaccompanied by other distinctive features, to justify the elevation of the group to the position of a genus, nor in fact do all the species concerned show the disparity between the second and third arms to such an exaggerated degree as *scorpio*. Although the "Challenger" *bandensis* has enlarged third arms they are only 1·2 times larger than the second, and those of Massy's *bandensis* are only 1·6 times larger. It might even be questioned whether the "Challenger" *bandensis* should be treated as anything but a normal *Octopus*.

To conclude, I think it desirable to retain this group as constituting a distinct subgenus, but with the proviso that the status of the four forms should be revised as soon as our knowledge of growth-change in these animals is more complete. Nearly all the species placed in this subgenus are pelagic.

* Except Appellöf's specimen of *M. bandensis*.

Octopus (Macrotritopus) equivocus, n. name.

Octopus gracilis, Verrill (1884*a*, p. 236, preocc. (Eydoux & Souleyet, 1852, p. 13)).

Holotype.—In Mus. Yale University (one ♀).

Distribution.—S. of Cape Sable, Nova Scotia, 40° N., 67° W.; (" Albatross "), in 1290 fathoms. Only known from the type locality.

Description.—The body is slender, elongate and rounded posteriorly. The eyes are prominent and the head only a little narrower than the body. The arms are in the order 3.1 = 2.?4. The third pair measures 42 mm.; Nos. 1 and 2 measure 19 and 21 mm. respectively. The fourth arms are both broken. The third arms are 79% of the total length. The web is low and probably subequal; its dimensions are not given. The suckers are small. The first 3–5 on the lower pairs of arms are uniserial, an arrangement not found on the dorsal arms. The colour (in alcohol) is yellowish-white covered with large purplish chromatophores. There is a purplish spot in front of and behind the base of each sucker.

Maximum size.—53 mm.

Remarks.—Berry (1920, p. 300) points out that " *Octopus gracilis* " was employed for a different form (? *Tremoctopus*) by Eydoux and Souleyet (1852). I take this opportunity of providing a new name for Verrill's species. I do not think Berry's apprehension that his *scorpio* is conspecific with Verrill's *gracilis* has any foundation. The two forms are distinct in (1) bodily proportion, (2) relative length of the third arm and (3) first and second arms, (4) surface and (5) colour-pattern.

The single specimen was obtained from a very great depth. In the " Albatross " report (1883) it is not stated if a closing net was used. I strongly suspect that the specimen was taken near the surface.

Octopus (Macrotritopus) scorpio (Berry).

Polypus scorpio, Berry (1920, p. 299, Pl. 16, fig. 4).

Holotype.—In U.S.N.M., Washington.

Distribution.—Off Biscayne Bay, Florida; in 75-0 m. Only known from the type locality.

Description.—The body is ovate to piriform, " rounded or rounded-conic " behind. Head " distinctly narrower than body " (Berry), (in the figure it is about as wide as the body)! The eyes are large and the head is delimited by a nuchal ridge. The arms are in the order 3.2.4.1. The third arms are nearly twice as long as the second, and the latter again nearly twice as long as the first pair. They are about 79% of the total length (from the scale given with the figure). The web is delicate and very short (dimensions not given). The surface is nearly smooth; there is a fine granular papillation on the dorsal region.

The colour (in alcohol) is greyish-buff with a few scattered chromatophores, " the most conspicuous being a single pair near the median line on the head just in front of the nuchal region."

Maximum size.—22 mm.

Remarks.—See *Macrotritopus equivocus*.

Octopus (Macrotritopus) bandensis (Hoyle).

Octopus bandensis, Hoyle (1885, p. 227), *id.* (1886, p. 96, Pl. 7, figs. 2 and 10), Appellöf (1898, p. 566); *Polypus bandensis*, Massy (1916*a*, p. 201).

Holotype.—In Brit. Mus.

Specimen seen.—In Brit. Mus.

One from Banda : 89.4.24.40, (type).

Distribution.—Banda (Hoyle), Ternate (Appellöf); off Colombo in 26½ fathoms (Massy).

Description.—Appellöf's specimen is not fully described, so that it is uncertain if it is rightly diagnosed. It is important to notice that it is a much larger animal than the others.

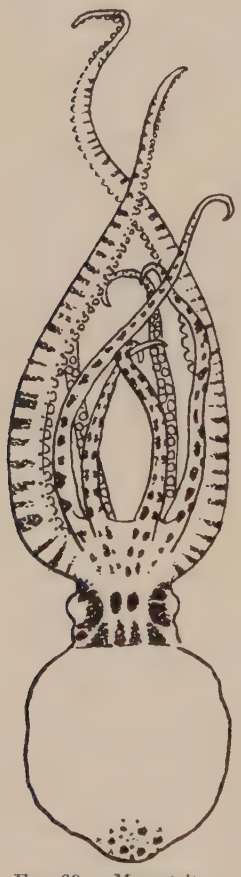


Fig. 60.—*Macrotritopus kempi*. × 3·4.

The mantle is roundish. The head in the type and Massy's specimen is very wide, either as wide as the body or a little less. There is a well-defined neck. The third arms are 1·2 (type) and 1·6 (Massy) times as long as the second pair, and are 80–89% of the total length. The web in the type specimen is destroyed; in Massy's specimen it is "very short . . . about equal all round . . . and forming large webs on the third arms," and is 11% of the arms in depth. The funnel is prominent. The surface of the type specimen is covered with small tubercles. In Massy's specimen the eyes are surrounded by prominent tubercles. The colour of this specimen is buff, with thinly distributed chromatophores forming patches below the eyes and on each side of the mantle. The arms "show dark patches on their outer surface arranged either in pairs or in single bars."

Maximum size.—66 mm. (Massy); 45 mm. apex-edge of web (Appellöf).

Octopus (Macrotritopus) kempi, Robson.

(Text-fig. 60.)

Macrotritopus kempi, Robson (1929*b*, p. 312).

Syntype.—Coll. R.S.S. "Discovery" (Brit. Mus.).

Specimen seen.—Coll. R.S.S. "Discovery."

Two ♀ from 5° 54′ S., 11° 19′ E. (off the mouth of the river Congo) in 110 fathoms (over 913–819 f.) ("Discovery," Station 276). (Syntypes.)

Distribution.—West Africa, off the mouth of the River Congo. Only known from the type locality.

Description.—Both specimens have globular bodies and the head in each is much narrower than the body (60–57% of the length). The third arms are 1·5–1·8 times as long as the second, and 72–78% of the

total length. The arms are usually in the order 3.2.4.1. The web is subequal and about 16% of the arms. The surface is entirely smooth and there are no cirrhi. The colour is buff covered with reddish-brown chromatophores which are arranged as follows: (1) a mass below and between the eyes; (2) a sparse scattering on the ventral mantle; (3) an apical patch on the dorsal mantle surface; (4) on the arms there is a chromatophore just beside each sucker and a double row on the dorsum of the arms. These are less distinct on the fourth arms.

The radula is normal and like that of *Octopus* (s.s.).

Maximum size.—47 mm.

Remarks.—This is a very distinct form. It is not unlike *M. bandensis* in colour-pattern; but differs in (1) bodily proportions, (2) surface, (3) the size of the web. There are chromatophores between the suckers as in *equivoca*, but that species differs very plainly in (1) the proportions of the third arm, (2) proportion of mantle and head and (3) certain features of the colour.

The interesting feature of this animal's habits is the fact that the circumstances of its capture suggest that it is pelagic. It was taken in a net at a depth of 110 fathoms in water of 913–819 fathoms, and therefore must have been swimming at a considerable distance from the bottom. The rest of the haul contained no benthic organisms. The station at which it was taken was 10 miles off the edge of the continental shelf and thirty-five miles from land.

The specific name *kempi* is given to this species as a tribute to the work of Dr. S. Kemp, Director of Scientific Research, R.R.S. "Discovery."

Octopus (Macrotritopus) elegans, Brock.

(Text-figs. 61–62.)

Octopus elegans, Brock (1887, p. 597).

Holotype.—In Zool. Mus., Göttingen.

Specimen seen.—One (♀) from Amboina, in Zool. Mus., Göttingen. (Holotype.)

Fig. 61.—*Macrotritopus elegans.* Mantle. (Type.) × 2·2.

Fig. 62.—*Macrotritopus elegans.* Funnel-organ.

Distribution.—Amboina (only known from the type locality).

Description.—The visceral sac is elongate-oval in shape and gently rounded apically. The eyes are very large and prominent. The arms are in the order 3.2.4.1. (2 and 4 almost equal in length), very slender and long (83%). The suckers are relatively small and widely spaced. The web is uniformly developed in all its sectors, but is very low (6%). The funnel is relatively large and pointed. The surface is soft and flabby and is entirely smooth. According to Brock the milky-white ground-colour of the dorsum and outer surface of the arms was finely dotted with purplish red. The mantle-aperture is widely open (C). The funnel is free for one-third of its length. The funnel-organ is not well enough preserved for me to describe it.

Total length.—120 mm.

Remarks.—The body is very much distorted in the only available specimen. It bears a fairly close likeness to *O. amboinensis*, but differs in (1) size and order of arms, (2) the funnel and (3) shape of the head and mantle. The form of the body, character of the arms, eyes and suckers confers on this animal a marked resemblance to the Ocythoidae (Brock, *l.c.*, p. 598), though the chief features of that group (water-pores, characteristic adhesive organ) are absent. There seems to be no reason why this form should not be included in *Macrotritopus*.

Subgenus iii. **Tritaxeopus,** Owen, 1881.

Type of the subgenus.—Tritaxeopus cornutus, Owen, 1881.

This genus was founded by Gray for a form distinguished from the other Octopodine genera by the possession of *three* (instead of two) longitudinal rows of suckers on all the arms. The species *T. cornutus* does not otherwise differ in any important respect from other forms of *Octopus*, as far as Owen's incomplete description goes, unless it be in the occurrence of carunculated eyelids carrying very heavy cirrhi.

The type of *T. cornutus* cannot be traced. Mr. R. H. Burne, F.R.S., has kindly made a search, which proved fruitless, in the Museum of the Royal College of Surgeons, where its presence was to be suspected.

It is highly unlikely that Owen would have been misled by some irregularity of the suckers into believing that there were actually three longitudinal rows. I have never seen a specimen in which there was any such accidental irregularity, though occasionally I have encountered two or more pairs of suckers overlapping somewhat. Until the type of *T. cornutus* is recovered or other specimens are discovered, we have no option but to maintain the group, though from the only available description it does not seem worthy of more than subgeneric status.

Octopus (Tritaxeopus) cornutus, Owen.

Tritaxeopus cornutus, Owen (1881, p. 131, pl. XXII); Cox (1882, pp. 781, 783).

Holotype.—Not traced.

Distribution.—" Australia " (where ?).

Description.—The mantle is narrowly ovoid, the head being rather narrower than the body. The eyes are very prominent. The arms are in the order 3.2.4.1. and long (83% of the total length).* The suckers

* Calculated.

are, as already described, arranged in three rows except a few at the base of each arm. The web is very low according to the dimensions given (2½ inches in depth on arms with a maximum length of 1 ft. 11 in. or about 10% of the arms). It seems, however, to be much longer in the figure (Pl. 23, fig. 1). It is prolonged as rather broad membranes up both sides of all the arms except the dorsal edge of the first pair. The mantle-aperture is very wide (C). The surface is covered, apparently rather sparsely, with warts, of which four or five have a longitudinal arrangement on the dorsal surface. These warts are also present on the base of the arms. Even making allowance for the apparently exaggerated figure, the eyelids are heavily carunculated and seem to bear large and heavy cirrhi from which the specific name is derived.

Maximum length.—(?) 668 mm. (calculated).

Subgenus iv. **Macroctopus,** Robson, 1928.

Type of the subgenus.—Octopus (*Macroctopus*) *maorum,* Hutton.

Definition.—The cephalic element of the locking apparatus is reduced to two small ridges on each side of the funnel. The gills are long, and there are 13–14 filaments in each demibranch. The hectocotylus is long. The suckers of the distal part of the arms in the female are converted into papillae. The body is long and slender.

On first studying the two specimens of *M. maorum* in the British Museum, and the relevant literature, I was struck by the assemblage of peculiar characters which this species presents. At the time I had not had the opportunity of seeing a large array of examples of *O. macropus,* and, though I commented on the similarity between the two species in certain respects, I was not aware that many of the characters which I thought to be peculiar in *maorum* are found in Oriental specimens of *O. macropus.* It is now apparent that the two species have a great deal in common. Whether they should be treated as identical is another matter, and one which we can only settle by a further study of fresh or living New Zealand forms.

Some of the characters which I originally employed in the diagnosis now seem to me to be of little systematic value. The extensive septum is highly interesting; but I am not sure whether it may not be adventitious. The lack of a funnel-organ is of no importance, as it is sometimes absent in individuals of a species normally possessing it. On the other hand, the character of the locking-apparatus, the numerous gill-filaments, the sexual dimorphism described by Suter and the long narrow body collectively render the species very distinctive.

The size and order of the arms, web-shape and depth, body-shape and certain features of the radula (the curiously recurved stout third laterals) are very like those of *O. macropus.* The hectocotylus of an undoubted Japanese *O. macropus* in the Leipzig Museum is very like that of *M. maorum.* On the other hand, the sculpture of *O. macropus* never takes the form of low, broad warts as in *M. maorum.* The colour of *M. maorum* is regularly described by New Zealand observers as dark greyish, and in the specimens in the British Museum, which have a trace of marbled pattern, there is no sign of the warm brownish or reddish found even in preserved specimens of *macropus.* Finally *O. macropus*

never attains the great size which *M. maorum* reaches. However, the resemblances are sufficiently striking to lead one to suppose that *maorum* may possibly prove to be a local derivative of *macropus*, which has found in New Zealand waters conditions exceptionally favourable for growth and differentiation. It is very puzzling that *maorum* should retain such a strong general likeness to *macropus* and yet differ so markedly in other respects. For the time being I propose to maintain the subgeneric status, but as *macropus* differs from *maorum* in certain particulars it must be excluded from that group. So far as we can discuss the phylogeny of the Octopodinae, it would seem that *Macroctopus* represents the most highly evolved stage in that group of *Octopus*-like forms in which *macropus*, *ornatus*, etc., are placed (p. 33).

Octopus (Macroctopus) maorum (Hutton).

Octopus maorum, Hutton (1880, p. 1); *Octopus Maorum*, *id.* (1882, p. 162, Pl. VI); *O. maorum*, Parker (1885, p. 586); *O. maorum*, Filhol (1885, p. 520); *Polypus maorum*, Suter (1913, p. 1064); *Macroctopus maorum*, Robson (1928*d*, p. 257, figs. 1–6).

Syntypes.—In the Otago Museum, Dunedin, N.Z., and Canterbury Museum, Christ Church.

Specimens seen.—In Brit. Mus.

Two specimens (♂♂) from Dunedin and Wellington, New Zealand: 86.11.18.1. and 73.12.10.1.

Distribution.—Dunedin (Hutton); Stewart Id. and Campbell Id. (Filhol); Lyttleton, etc. (Suter); Wellington (Brit. Mus.). A littoral form found among rocks.

Description.—The mantle and the head are extremely narrow, the head being, I think, the narrowest in the subfamily. There is a well-defined "neck" and preocular constriction. The arms seem to be in the order 1.3.2. = 4, but our two specimens are males, and the third right arms are shorter than their fellows of the opposite side. They attain a length of 81—87% of the mantle-length. The mantle-aperture is very wide (C). The suckers attain a maximum diameter of 10–15% of the mantle-length and show no special enlargement. The web has the formula A.B.C.D.E. and is rather shallow (18% of the arms). It sends well-developed extensions up the dorsal and ventral sides of the arms.

The gills have more filaments than is usual in the genus, viz. 13–14 in each demibranch. The septum is very long and almost complete (cf. Robson, *l.c.*, p. 261). The funnel is free for only one-quarter of its length, and its locking apparatus is very weak, consisting only of two small lateral ridges. The radula had a rhachidian with a very wide base and an A_3 seriation. The first lateral has a prominent cusp and a deep and rather narrow base. The second lateral is very heavy. It bears no entocone, and its heel is moderate in size. The third laterals have a straight shaft, but are markedly recurved at the tip. The marginals are rather degenerate. Hutton's figure (1882, Pl. VI) is somewhat diagrammatic and, I think, misleading.

The hectocotylized arm is markedly shorter than its fellow. The ligula is rather long (6·2–8·0%). It is well formed, its median groove

being clearly marked and traversed by 9–10 laminae. The penis is long and very narrow, and has a small and carunculated appendix.

In the female the distal suckers of all the arms are reduced and converted into papillae (cf. the male of *O. chierchiae*, p. 152). The surface of the body bears traces of obscure, low, broad warts. The colour is pale ochre marbled with greyish purple (spirit specimen).

Maximum length.—6 ft. 6 in.

Remarks.—See under genus.

Octopus (Macroctopus communis) (Park).

Octopus communis, Park (1885, p. 198); *Polypus communis*, Suter (1913, p. 1063).

Holotype.—Originally in the Nelson Museum; destroyed by fire.

Distribution.—Blind Bay (Nelson), New Zealand (only known from the type locality).

Description.—The mantle is oval, stout and "fan-shaped behind." The head is large (? wide) and long, with prominent eyes. The arms are subequal and in the order 1.2 = 3.4, the longest being about 73% of the total length. This figure (as well as other proportions) is uncertain, as Park gives "circumference of body," and length of "body and head" (?) only. The suckers are widely alternating ("not opposite," Park), the largest being about 10% of the mantle. The web is not mentioned. The hectocotylized arm is $\frac{6}{11}$ of its fellow in length and the ligula is "long and flattened" with a deep groove. The surface is smooth and its colour is dark steel-grey, on the dorsal surface blotched irregularly with pale grey and almost black round the eyes. Below it is paler and the blotches smaller and less numerous.

Remarks.—This species is placed in the same genus as *M. maorum*, which it resembles in certain important respects; but it is not described with sufficient fulness to enable us to decide how closely it is related to that species. The two forms seem to be rather similar. But (1) the shape of the body and head, (2) the ratio of the arms to the body and (3) of the third right arm to its fellow seem to differentiate them. *Communis* is described as smooth and *maorum* has a sculptured skin. I am a little inclined to discount the early accounts of sculpture, as some specimens originally described as smooth are subsequently found to have obsolete warts. The size of the ligula (not given exactly), the colour, arm-formula, and the rather marked superiority in length of the 1st arms are characters shared in common. Suter does not discuss its relationship to *maorum*, and I think that, had there been any real grounds for believing it to be synonymous with the latter, he would have mentioned them.

Subgenus v. **Enteroctopus,** Rochebrune & Mabille, 1889 (?).

Type of the subgenus.—Enteroctopus membranaceus, Rochebrune & Mabille.

Definition.—Octopods with subgelatinous (?) tissues, the arms, radula, hectocotylus, web and mantle being like those of *Octopus* (s.s.). The penis has a long and tubular appendix, the external part being very small.

The first reference which I can find to this group is that of Rochebrune and Mabille in the "Cap Horn" studies (1889). The authors refer to a

previous description of their own (1887), which, however, I cannot find. Grimpe (1922) and Hoyle (1910) both refer to the later date, not to the earlier. I assume that the earlier description never actually appeared.

The genus is not defined in the " Cap Horn " report, which contains a citation of the name and a description of *E. membranaceus*, R. & M., " 1887," and *E. megalocyathus*, Gould. The first-named species is very superficially described, but was fixed as the type by Hoyle (1910, p. 409). From the description the type specimen was most certainly a young example. *E. megalocyathus* is fortunately figured and more adequately described by Gould (1852, p. 471). The British Museum collection contains some specimens from the type area which can be readily identified with Gould's species. It therefore follows that we can form a good idea of Rochebrune and Mabille's genus. But if the strict rules of nomenclature are to be followed and we accept Hoyle's determination of the genotype, it follows that the latter is a young, imperfectly described form and not the adult, well-figured and adequately described *megalocyathus*. Concerning the status of this group I am more than a little doubtful. A careful collation of all the evidence seems to indicate a form differing only in one marked particular from *Octopus* (s.s.). The arms, hectocotylus, web, suckers, shape, gills, ink sac, radula offer no feature of outstanding peculiarity. Gould describes a narrow lateral pallial expansion (like that of *O. membranaceus*, Quoy & Gaimard; but I am sceptical as to the systematic value of this structure (cf. p. 7). It is not mentioned in *E. membranaceus* by Rochebrune and Mabille. The outstanding feature of this subgenus and one which effectively distinguishes it from other Octopods is the penis. This has a remarkably long and narrow diverticulum and a very short anterior part. This very marked peculiarity (see p. 16) may justify the retention of the group as a subgeneric one. All our specimens are gelatinous, the pallial musculature is reduced and a subepidermal layer of gelatinous tissue is laid down. In one specimen, however, this is not very noticeable, and I am very doubtful as to the systematic value of what may be after all an effect of preservation.

Enteroctopus megalocyathus (Gould).

(Text-figs. 63–65.)

Octopus megalocyathus, Gould (1852, p. 471, Pl. 45, fig. 586), Cunningham (1871, p. 474, not *O. tehuelchus*, Orb., as Hoyle (1889, p. 218)); *Enteroctopus megalocyathus*, Rochebrune & Mabille (1889, p. H8); ? *Octopus patagonicus*, Lönnberg (1899, p. 50); *Polypus brucei*, Hoyle (1912, p. 276, figs. 2–3); ? *Octopus Brucei*, Odhner (1923, p. 6).

Type specimen.—? In U.S.N.M., Washington (? Holotype.)

Specimens seen.

(*a*) In Brit. Mus.

Two specimens (♂) from Gregory Bay, Str. of Magellan: 68.7.1.1. One specimen (♂) from Sandy Point, Tierra del Fuego: 68.6.29.50. One specimen (♀) from Baija (?) Bay, Str. of Magellan (unregistered).

(*b*) In the Royal Scottish Museum.

One (♂) from Burdwood Bank, Tierra del Fuego (type of *P. brucei*, Hoyle).

Distribution.—Orange Harbour, ? Tierra del Fuego, (Gould); Straits of Magellan (Cunningham); Straits of Magellan and Tierra del Fuego (B.M.); Falkland Is. and Beagle Channel (Odhner); Burdwood Bank, Tierra del Fuego (Hoyle).

Structure, etc.—The mantle is ovoid or broad; the head is usually small (70–36%) and marked off from the mantle by a constriction. Its surface is smooth and of a purplish or chocolate-brown colour above. In three out of four specimens the tissues are highly gelatinous. The arms are usually in the order 1.2.3.4., and are 78–83% of the total length. The mantle-aperture is rather wide (B–C). The largest suckers are 16–11% of the mantle-length in our specimens, 17% in Gould's and 20% in Hoyle's *brucei*. Enlargement of the suckers occurs on all the arms, but in no case is it abrupt, and there is no difference between the sexes in this respect. The web probably has the formula A.B.C.D.E., the first four segments

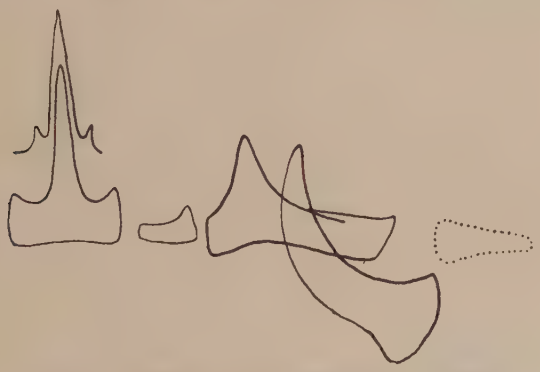


Fig. 63.—*Enteroctopus megalocyathus.* Radula.

being subequal and the last markedly smaller. It is 23–15% of the longest arms, and its disparity-index is 41–20. It is continued up the arms almost to their extremities.

The funnel is moderately prominent. The funnel-organ is W-shaped in one British Museum specimen. The locking apparatus is weak. The gills are not well preserved in our specimens, but in one example there are eleven filaments in each demibranch. The radula has a rhachidian with a symmetrical A3–5 seriation. The first laterals have a high cusp. The second laterals have a very feeble "heel" and a prominent cusp. The third laterals are heavy and curved. The marginals are degenerate. *Reproductive organs.* The hectocotylus is 4·8–8·6% of the 3rd arm in length and is long and pointed. The calamus is very minute. The sides of the ligula are folded inwards (markedly in "*brucei*"). The seminal groove is rather weakly developed. The penis has a long and tubular appendix and a very short apex.

Maximum size.—43 in. (Gould).

Habits, etc.—Such data as are available point to the species being a littoral one. Otherwise nothing is known concerning its habits.

Variation.—Gould's specimen (the type) is not exactly like the specimens which I have seen, nor do the latter agree amongst themselves in all

respects. I am quite convinced that these specimens are correctly identified as belonging to Gould's species; yet Gould's type has a much narrower head (36%). The majority of the other specimens, including Hoyle's "*brucei*," have a wide head (70–43%). Again, the type of *brucei* has a very wide body, while Gould's and one of those in the British Museum are far narrower (66–67%). Were not all these specimens so much alike in other respects, I should be inclined to treat them as varietally distinct.

Remarks.—Hoyle (1889, p. 218) considers that Cunningham's *megalocyathus* is the same as Orbigny's *O. tehuelchus*. I am inclined to treat the two forms as distinct. Neither of the species was well described to begin with. The specimens in the Museum which enable me to supplement

Fig. 64.—*Enteroctopus megalocyathus*. Hectocotylus. × 13.

Fig. 65.—*Enteroctopus megalocyathus*. Penis. × 3.

our knowledge of *megalocyathus* give no grounds for identifying *tehuelchus* with the latter.

The two species seem to differ essentially as follows: (1) the head of *megalocyathus* is on an average narrower than that of *tehuelchus*, and the mantle is oval, not circular. (2) The order and relative size of the arms differs. (3) The funnel of *megalocyathus* is short, that of *tehuelchus* long. Furthermore, I think that if Orbigny's species had had the large suckers characteristic of Gould's form he would have mentioned the fact.

At the same time it must be pointed out that *megalocyathus* is by no means homogeneous. Our specimen No. 1 has a wider head and a less oval mantle than those seen in Gould's figure or in our other specimens. Indeed, our specimens Nos. 1–2 are not very typical in build. They are much smaller than the adults; but as they resemble the latter in many other respects, I feel justified in including them here. There is marked dimorphism (not sexual) in respect of the head- and body-width. Concerning Hoyle's *brucei*, I have not the least doubt that this is identical with *megalocyathus*. The order and the length of the arms, size of the funnel, the hectocotylus, radula, colour and surface all agree with those

features in *megalocyathus*. The rhachidian of the radula seems more asymmetrical than that in our specimens. Otherwise it is identical. The head is broader than in all our *megalocyathus* and in the type specimen, but it is like that of our extreme *megalocyathus* variant. The calamus and seminal groove of the hectocotylus are both more distinct than in our specimens. Hoyle himself was in doubt as to the real status of the type of *brucei*; but he decided that it should be regarded as distinct from *megalocyathus* owing to (*a*) the absence of a constriction between head and mantle in *brucei* and of the natatory membrane described by Gould, and (*b*) the uncertainty whether the enlarged suckers found on all the arms in *brucei* are likewise situated in *megalocyathus*. However, (*a*) does not seem to be important, as neither the natatory membrane nor medial constriction are a regular feature of our material, the former being admittedly an unsatisfactory diagnostic feature. As for (*b*) the suckers are enlarged on all the arms of our specimens, though it should be noted that those of Hoyle's specimen are larger.

For *O. patagonicus*, see p. 149.

Enteroctopus membranaceus, Rochebrune & Mabille.

Enteroctopus membranaceus, Rochebrune & Mabille (1889), p. H7.

Type specimen.—Unknown (? Holotype.)

Distribution.—Orange Bay, Cape Horn. Only known from the type locality.

Description.—The body is saccular and narrow, its width being 45% its length. The head is small and the eyes moderate. The arms are filiform at the extremity, and the median (? longest) are 76% of the total length. The web is extensive and is continued up each side of the arms as a wide membrane. The suckers diminish in size from the base of the arms to the extremity. The body is smooth and of a pale violet colour, yellowish below and with the arms marbled with deep violet.

Maximum size.—85 mm. (?).

Remarks.—As in the case of *E. megalocyathus* the authors refer to an earlier date of publication (1887). No work of theirs can be traced to that year.

This immature and incompletely described form cannot be assigned with certainty to any known species. It may be a young example of *megalocyathus* or of *eureka*.

Enteroctopus eureka, n. sp.

(Text-figs. 66–68.)

"*Polypus tehuelchus*, Orbigny," Hoyle (1912, p. 278, figs. 4–5, not *O. tehuelchus*, Orb.).

Syntypes.—In the Royal Scottish Museum, Edinburgh.

Specimens seen.

(*a*) In Brit. Mus.

One specimen (♂) from the Falkland Is. (J. Hamilton) : 1920.3.21.1.

(*b*) In the Royal Scottish Museum.

Two specimens (♂♀) from Port Stanley and ? loc., Falkland Is. "Scotia"). (Syntypes.)

Distribution.—Only known from the Falkland Islands.

Description.—The mantle is saccular and the head only a little less wide than the mantle. The arms are moderately long, viz. 79–81% of the total length. The suckers are not particularly large (even in the male specimens) and there is no abrupt increase. The web is shortest between the dorsal arms, widest in interspace C. The formula is C.B.D. = E.A. or E = A and the length of the web is 23–28% of the longest arm. The mantle-aperture is fairly wide (B–C). The funnel is short and free for half of its length. If Orbigny's figure (Pl. 17, fig. 6*a*) is to be trusted, the relation of the funnel to the eyes is very different from that seen in *O. tehuelchus*, as the funnel arises much lower down in *E. eureka*, its upper border being in the same line as the anterior border of the eye. The funnel-organ is not well preserved. The skin is smooth, but there may be traces of obscure granulation. The general colour is dark purple with irregular patches of pink on the dorsum. *The radula.* The rhachidian is multicusped. The first lateral is very characteristic, having a very large cusp and a markedly rectangular base. The second lateral, like that of *Enteroctopus* sp. (p. 181) and *Benthoctopus*, has a very short base, no entocone and a low and heavy mesocone.

Fig. 66.—*Enteroctopus eureka.* Male reproductive organs. × 2·4.

The reproductive organs. (*a*) Hectocotylus. This is a little damaged, but it is evident that the ligula is long and slender, the calamus very short and adjacent to the last sucker. (*b*) The penis has a long cone-shaped diverticulum, which is usually over five times as long as the terminal part. The anterior part of Needham's organ is very much swollen, the apical part slender. The accessory glandular structures of the vas deferens are singularly ill-developed, only Meyer's "glandula spermatica" being at all marked.

Habits, etc.—There is nothing known concerning this form.

Maximum size.—294 mm.

Variation.—I have examined Hoyle's "Scotia" specimens named "*tehuelchus*" by him. I believe that these are referable to the same species as the British Museum specimen of *eureka*. The male differs in certain minor respects, however. (1) The body is much wider and (2) the head rather broader, (3) the suckers attain a greater diameter, though it must be noted that the suckers are in a different state of contraction, and the web is distinctly deeper. The skin of both Hoyle's specimens is

very much wrinkled, and it is hard to say how much and what kind of sculpture was present.

Remarks.—It is with some hesitation that I treat this form as a distinct species. It has many features in common with *megalocyathus*, and in particular with the broad headed form of the latter. Never-

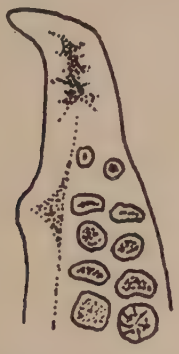


Fig. 67.—*Enteroctopus eureka.* Hectocotylus. (After Hoyle and Type.) × 2.

Fig. 68.—*Octopus eureka.* Penis.

theless, it differs from that species in (*a*) the shape of the web, (*b*) the size and shape of the appendix penis, (*c*) the form of the radula and the proportions of the mantle. It differs from *O. tehuelchus* in (1) the position of the funnel, (2) the shape of the web, order of the arms, and (3) the lack of sharp contrast in colour between the dorsal and ventral surface of the arms. It nevertheless has characters in common with both *megalocyathus* and *tehuelchus* and may be closely related to them. It may be synonymous with Rochebrune and Mabille's *membranaceus*, as the maculation of the arm suggests. It must be remembered that the identity of *O. tehuelchus* (p. 147) is very obscure, and until it is clearly established it is better to treat *O. eureka* as a distinct species.

(?) **Enteroctopus,** sp.

(Pl. VI, f. 3; text-fig. 69.)

Polypus brucei, Massy (1916*b*, p. 151).

Specimen seen.—One specimen (♀) from Rio de Janeiro : 1919.12.30.46.

Distribution.—Only known from the above-named locality.

This immature form was referred by Massy to *O. brucei*, which is now regarded as identical with Gould's *megalocyathus*. A study of the external form would incline one to accept Massy's view. Such of the external parts as are available for study (having regard to the small size of the animal) show a general resemblance to Gould's species, viz. the arms (order and size) and the web proportions and size. The disparity index is very low, however, and the various sectors of the web are subequal. This might be due to immaturity. The suckers again are more or less equal in size and only 9% of the mantle-length. This again might be due to age. Lastly, and perhaps most important, the radulae are very different.

(*a*) The rhachidian of *Enteroctopus* sp. is regularly unicusped (very occasionally traces of ectocones are seen), and its mesocone is lower and stouter than that of *megalocyathus*. Relatively to the base the mesocone is in the proportion of 40 : 48, instead of 60 : 89. (*b*) The first lateral has a low, coarse cusp instead of a high and acute one. (*c*) The second lateral has a very narrow base to which the cusp stands as 37 : 26 instead of as 42 : 77 (*megalocyathus*), a condition seen in *E. eureka* and *Benthoctopus*. (*d*) The third lateral is not like that of *brucei* (Hoyle, *l.c.*, fig. 3), as Massy states, as the shape of the base differs. (*e*) The marginals are well formed, not degenerate as in *megalocyathus*.

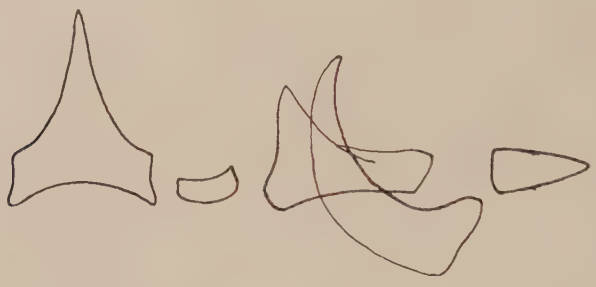


Fig. 69.—*Enteroctopus* sp. Radula.

For the time being it seems better to suspend our judgment as to the status of this form. Its actual subgeneric position is doubtful.

Genus 2. **Cistopus,** Gray, 1849.

Type of the genus.—Octopus indicus, Orbigny.

The velar interspaces are occupied by a series of pouches imbedded in the web and opening on the oral surface of each interspace. ? Hectocotylus undifferentiated.

This genus was created by Gray for Orbigny's *Octopus indicus*, principally on account of the occurrence of "a small aquiferous system consisting of a bag with a small pore at the outer edge situated between the bases of the arms." The other generic characters cited by Gray are unimportant. The statement "eyes covered by the skin" is erroneous. Since Gray's description there has been no further description of *O. indicus*, so that I take this opportunity of giving a full description of the structure (as far as is possible from the limited amount of material at my disposal) of the genotype.

Cistopus indicus (Orbigny).

(Text-fig. 70.)

Octopus indicus, Orbigny (1840, p. 24, Pl. 26, ? not Pl. 25); *Cistopus indicus*, Gray (1849, p. 20), Tryon (1879, p. 127), Martens (1880, p. 727), de Rochebrune (1882, p. 73); *Cistopus bursarius* (Steenstrup MS.) in Hoyle (1886, p. 14), Channappayya (1927, p. 109).

Syntype.—In M.H.N., Paris.

Distribution.—India, China (B.M.); Celebes (Orb.); "Sth. African . . . region" (Hoyle, 1889, p. 223, ?); Mozambique (Martens); Poulo Condore (Indo-China) (de Rochebrune, 1882); Gulf of Manaar (Channappayya).

Specimens seen.

(*a*) In Brit. Mus.

One specimen (A) (♂) from India (Hardwicke) (old collection): 1927.11.19.1. One specimen (B) (♂) from China (source ?) old collection: 1927.11.19.2.

(*b*) In M.H.N., Paris.

One (♀) from Celebes (Rapp.) (? Type). One (♂) from Bombay (Roux, 1868).

*Description.**—The visceral sac is long and narrow in male specimens, broad in the female, and the interocular width is very narrow. The surface is smooth on the ventral surface and sides, rugose and covered with fine low and widely spaced warts on the dorsum. This sculpture is more apparent in specimen B (Brit. Mus.). Specimen A, which is less well preserved, is nearly smooth all over. In both specimens the remnants of a dull purple coloration are found on the dorsum only. The arms are in the order 1.2.4.3., and are 87–84% of the total length in A, 84% in B, and 87% in Orbigny's adult. The suckers are diagonally arranged, almost linear, and prominent. The tenth sucker of arms 1 and 2 is very much enlarged, attaining 17% (Brit. Mus. A) and 13% (B) of the mantle-length. The web is variable and may be in the order A.B.C.D.E. (usually) or B = C.A.E.D., etc. It attains a depth of 13–18% of the longest arm and is very slightly extended up the sides of the arms.

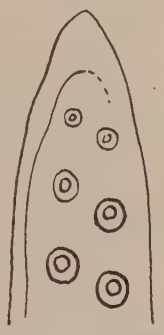


Fig. 70.—*Cistopus indicus*. Hectocotylus. × 6.

The gills have 11–10 filaments a side and the inner demibranch is markedly reduced in depth, being about only two-thirds the depth of the outer. The funnel is very prominent. There are traces in each specimen of a simple **W**-shaped funnel-organ.

The *radula* calls for some particular comment. The median tooth is of a simple tricusped type without seriation. The second lateral has a marked keel, no endocone, and the external limb is very narrow. The third laterals have narrow bases. The marginal plates are either very degenerate or absent. The ink sac has a long and slender duct and is either wholly or partly buried in the surface of the liver. In both our specimens the sac itself is rather small.

The hectocotylus is only well seen in specimen B. It is singularly undeveloped. There is scarcely any ligula at all, the seminal groove ending almost at the tip of the arms, the slightly modified tip of the arm measuring only 1·4% of the length of the arm. No calamus can be made out. As this undeveloped state was found in two forms and both of the latter were fully mature, I assume it represents the adult form. The penis is like that of *Octopus vulgaris*. In the Bombay specimen (Paris) the anterior part is rather longer than usual. The spermatophores are very numerous; they measure about 18–20 mm.

* Orbigny's form and the specimens in the British Museum treated as conspecific.

The *velar pouches* are eight in number. They are situated between the bases of the arms, communicating with the exterior by a subterminal pore situated at the inner end at about the level of the third sucker. Each pouch measures about 10 + 4·5 mm. in specimen A; in specimen B they are smaller. They are self-contained and send out no apparent branches or diverticula. Interiorly their surface appears to be trabecular. In Orbigny's figure (Pl. 26) the pores open between the fourth and fifth suckers. The function of the pouches is unknown (see p. 8).

Maximum length.—560 mm. (Orbigny); 570 (type, G.C.R.).

Variation.—See *Remarks*.

Remarks.—Orbigny's description (1840) is quite definitely devoted to the recognizable species possessing the generic character above described. In his first plate (Pl. 25) he figures a specimen not at all like the forms otherwise recognizable as *Cistopus* in our collection. (1) The mantle-sac of this specimen is purse-like and very wide; in ours it is narrow and elongated. (2) The arms are provided with very wide lateral membranes which are absent in our specimens. Steenstrup (MS. in Hoyle, 1886, p. 14) suggested that Pl. 25 shows an *Octopus* which (presumably) was figured in mistake for the *Cistopus* received from Rapp. He therefore proposed to recognize the form figured on Orbigny's Pl. 25 as an *Octopus*, to which the name *indicus* should be given, and to call the *Cistopus* figured on Pl. 26 *C. bursarius*. From this view I dissent, for the very strong reason that the type specimen in the Paris Museum, which resembles the specimen figured on Pl. 25, has the pores of a *Cistopus* and cannot be treated as an *Octopus*. While agreeing with Steenstrup that Pl. 25 shows a form very different in general build from those, *e.g.* in the British Museum collection, there is no doubt that it tallies with the textual description of *C. indicus* given by Orbigny. It is thus possible that Orbigny's *indicus* (Pl. 25) and ours may be different species of the same genus. As the three narrow examples are males and the broad one a female, the differences here discussed may be sexual in origin. I use the name *indicus* for the forms with elongate mantle as well as for that in which the latter is more purse-like, with the reservation that there may be two species involved. Orbigny's description tallies more or less with our specimens except in the two particulars mentioned (mantle-width and form of umbrella). Attention may be drawn to the fact that the type specimen has a width-index of $87\left(\frac{61 \times 100}{70}\right)$, whereas from Orbigny's Pl. 25 it would be calculated as $70\left(\frac{44 \times 100}{62}\right)$. Roux's specimen in the Musée d'Histoire Naturelle, Paris, has an index of 56 and is a male.

Genus 3. (?) **Pinnoctopus,** Orbigny, 1845.

Type of the genus.—*Octopus cordiformis*, Quoy & Gaimard.

Definition.—The visceral sac is completely encircled by a broad membranous expansion extending on each side almost to the level of the eyes.

A good deal of mystery enshrouds *O. cordiformis*, the type of this

genus. As figured by the authors, the lateral membranes are very wide and complete. They are conterminous with the mantle and confer on the animal a *Sepia*-like appearance. If they actually had the size and shape portrayed in the original figure, and were regularly present in all the members of the species, they would quite justify the creation of a genus for the species. As it is, we know (1) that such lateral membranes are often adventitious features in normal fin-less Octopods, and (2) that at least one early author exaggerated them in his drawing. Unfortunately the type of this species cannot be traced. There is a further ambiguity attached to the species. Quoy and Gaimard obtained it from New Zealand, and Filhol records it from Stewart and Campbell Islands and as " common " in New Zealand. Nevertheless, inquiry in New Zealand has failed to yield any knowledge of its actual occurrence to-day, and Suter in his " Manual of New Zealand Mollusca " merely cites earlier authorities, including " Hauraki Gulf " possibly from his own observation. It was apparently unknown to earlier naturalists in New Zealand (Hutton; Parker). I am tempted to suggest that it was probably a specimen of *O. maorum* having adventitious lateral folds.

The rest of the features described and portrayed by Quoy and Gaimard and Orbigny are those of a normal octopus. The internal and pallial anatomy is unknown.

I include here Berry's *O. kermadecensis* with some doubt. The generic status of this form, like that of the type species, is dependent on a fuller knowledge of the nature of the lateral membranes.

Pinnoctopus cordiformis, Quoy & Gaimard.

Octopus cordiformis, Quoy & Gaimard (1832, p. 87, Pl. 6, fig. 3), Orbigny (1840, p. 62, Pl. 10, fig. 1); *Pinnoctopus cordiformis, id.* (1845, p. 193), Hutton (1880, p. 1), Filhol (1885, p. 521), Suter (1913, p. 1065).

Type specimen.—Not traced (? Holotype).

Distribution.—Tasman Bay, N. Zealand (Quoy and Gaimard); New Zealand (Filhol); Stewart Id. and Campbell Id. (Filhol).

Description.—The mantle is broadly ovoid and surrounded by membranes which nearly reach the posterior border of the eye, and are at their maximum about half as wide as the mantle. Posteriorly they end in a blunt point. The arms are subequal and about 81% of the total length. They are very slender and attenuated towards their extremities. They are joined by a web which is about equally developed between all the arms, and is about 14–16% of the length of the arms. It is extended up the sides of the latter. The colour is in general reddish-brown, the head, arms and web covered with indistinct sky-blue lunulations. The fins are edged with light greenish blue.

Maximum size.—3 ft. 1 in. (Quoy and Gaimard).

Remarks.—This exceedingly handsome Octopod, which seems to attain a length of over three feet, is only known from the brief description of Quoy and Gaimard, who give no information about the habits, etc., of the animal.

Pinnoctopus (?) kermadecensis, Berry (? = **O. macropus** var.).

Polypus (*Pinnoctopus* ?) *kermadecensis*, Berry (1914*b*, p. 138); *Polypus kermadecensis*; *id.* (1916, p. 49).

Type specimen.— ? In the Dominion Museum, Wellington, N.Z.

Distribution.—Sunday Island, Kermadec Islands. Only known from the type locality.

Description.—The body is very narrow and encircled by a peripheral fold; the head is narrower than the mantle, and the eyes are very prominent. The arms are long * (72%) and slender and are in the order 1.2.3 = 4. They are very disproportionate in length, the dorsal arms being very much longer and stouter than the others. The suckers are mainly small, but are conspicuously enlarged just before the middle of each arm. There is a peribuccal circlet constituted, as in *O. taprobanensis*, by the minute first suckers. The funnel is free for a third of its length; its organ is unknown. The web has the formula (?) A.B.C.D.E., A being much deeper than E. It is on the whole shallow, being about 16% of the arms. The skin is smooth except for a few tubercles about the eyes and some scarcely distinguishable papillae on the dorsum. Colour, a dull brownish-grey streaked with slate-colour. The hectocotylus and radula are unknown.

Maximum size.—250 mm.

Remarks.—This form is only known from the single type specimen. Its generic position actually depends upon a fuller knowledge of the type of *Pinnoctopus cordiformis* and some clue as to the validity of that genus. In the meantime it is associated with the latter on account of the occurrence of a peripheral fold completely encircling the apex of the mantle. In *kermadecensis* the fold is conspicuous, attaining a width of half that of the visceral sac. As in *Sepia* there is an apical notch indenting the fold. Unlike those of *P. cordiformis* the "fins" do not seem to project beyond the mantle-margin. Whether this fold is a permanent feature or is mainly accidental (as is found in, e.g. *Bathypolypus arcticus*, etc.) cannot be decided at present. It is certainly evidence in its favour that *P. kermadecensis* occurs in tolerable proximity to the distributional area of *P. cordiformis*. On the other hand, Berry (*l.c.*, p. 139) reports two juvenile specimens from Sunday Island which "may possibly represent young stages of *P. kermadecensis*." These lack the peripheral fold.

I do not know whether Berry's subsequent assignment of this species to *Polypus* means that he withdrew his query as to "*Pinnoctopus*" on carefully considered grounds. He originally held that "in the smooth elongate body and predominating dorsal arms it approaches very closely the condition found in *P. macropus*, and this may prove something more than a mere coincidence." The depth and form of the web (as far as we can judge) contribute to this impression, and I am quite prepared, if future study of the anatomy shows us no deep-seated differences associated with the permanent occurrence of fins, to recommend this identification. This treatment of *kermadecensis* must inevitably strengthen our doubts

* Berry says "exceedingly long"; actually from his table of measurements they are $\frac{181 \times 100}{250} = 72\%$.

concerning the status of *Macroctopus maorum* and its relationship with the group of *O. macropus*.

Genus 4. **Joubinia,** new genus.

Type of the genus.—Octopus fontanianus, Orbigny.

Octopodines with the web about equally developed in all its sections and but little continued up the arms. The arms are subequal and the mantle-aperture is partly closed. The adlateral tooth of the radula is bicuspid (?). The penis has a second diverticle and a long primary diverticle (like *Enteroctopus*). The ligula of the hectocotylus resembles that of *Bathypolypus*, having markedly inrolled sides and wide " cheeks."

Although the two forms for which I propose this new genus are not in general very different from the members of the genus *Octopus* (s.s.) I do not consider it advisable to leave them in that group. The character of the penis and its diverticula is so striking and the hectocotylus is so plainly differentiated from *Octopus* that they require a special recognition. The form of the web and certain features of the radula, although not altogether without parallel in *Octopus*, are likewise very strongly characterized and, with the features already mentioned, form a complex of characters quite unknown in the allied genus. The form of the penis allies this genus with *Enteroctopus* and *Scaeurgus*. *Joubinia* and *Enteroctopus* seem to constitute a fairly distinctive Magellanic group. We may distinguish in certain features a suggestion of relationship with the Bathypolypodinae.

Orbigny (1840) alludes to the existence of " aquiferous pores " in his *O. fontanianus* similar to those of *Cistopus*. I have not succeeded in finding them in any of our specimens.

Joubinia fontaniana (Orbigny).

(Text-figs. 71–72.)

Octopus fontanianus, Orbigny (1835, p. 28, Pl. II, fig. 5), *id.* (1840, p. 49, Pl. 28, fig. 5, Pl. 29, fig. 1), Tryon (1879, p. 123), Rochebrune and Mabille (1889, p. 6), Joubin (1898, p. 23), *id.* (1906, p. 1, figs. 7–8), Lönnberg 1899, p. 49); *Polypus fontani(e)anus*, Dall (1909, p. 181), ? Massy (1925, p. 224), ? *Octopus fontanianus*, Winckworth (1926, p. 325); *Polypus fontanianus*, Berry (1914*a*, p. 299); not *Polypus fontanianus*, Robson (1921, p. 437), Robson (1925, p. 104 (Radula)).

Type specimen.—? In M.H.N., Paris (? Holotype.)

Specimens seen.

(*a*) In Brit. Mus.

One (♀) from Chile : 99.8.31.84. One (♂) from Chile : 51.1.24. One (♀) from Valparaiso : 48.6.16.2. One (♀) Lota, Peru : 69.6.5.63. Three (♀♂♂) from Coimba : 69.6.5.62, 65, 69. One (♀) from N. Patagonia : 51.1.24.12. One (♂) from Hattadura Bay : 69.6.5.64. One (♀) from Sandy Bay, Straits of Magellan : 68.7.10.2. One (?) from Tierra del Fuego : 51.1.24.4.

(*b*) M.H.N., Paris.

Three specimens (♂) from Valparaiso (Gay, 1832. ? Syntypes).

(*c*) M.N.K., Berlin.
One (♀) from Peru (No. 676).

Distribution.—Peru, Chili, Patagonia, Tierra del Fuego, (Rochebrune and Mabille, Lönnberg, Dall, Orbigny, Brit. Mus.); ? Patagonia (Joubin); Natal (Massy); Indian Ocean (? where) (Joubin); Ceylon (?) (Winckworth); Sandwich Is. (?) (Tryon). See remarks on p. 189. Recorded erroneously from Coetivy Atoll, Indian Ocean (Robson).

Definition.—The mantle is broad and saccular, its width averaging 96% of its length (4 specimens). The head is rather narrow, being on the average 67% of the length of the mantle. Our specimens agree herein with those of Orbigny. The arms in our specimens are longer than the latter, averaging 77% of the total length, and they are more unequal in length. In Orbigny's example they are almost all equal: in ours there is some disparity in size, though the difference never exceeds 13% of the longest

FIG. 71.—*Joubinia fontaniana*. Penis. × 2·6.

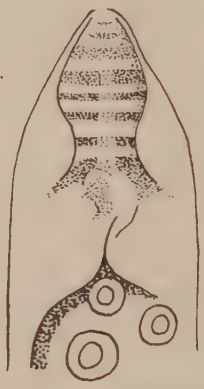


FIG. 72.—*Joubinia fontaniana*. Hectocotylus. × 5·5.

arm. The suckers, as in the type specimen, are usually rapidly enlarged at the fourth pair on the second and third arms. The sections of the web are subequal, E usually being slightly smaller than the others. The depth is generally 23% of the longest arms. There are no extensions up the arms. The pallial-aperture is moderate in width (B). The surface of the body is covered fairly closely with small, clearly defined, mainly circular warts and granules, occasionally enlarged on the dorsum with cirrhi or less often joined up as ridges on the sides. There is a cirrhus over each eye. The colour in the living animal is apparently a reddish-purple, which is paler on the vertical surface and arms. It is, however (Orbigny), variable; specimens preserved in alcohol may exhibit shades of reddish-brown, brown or very pale purple.

The gills have 9–10 filaments.

The funnel-organ is usually W-shaped. The funnel is rather prominent and is free for about half of its length. The locking ridge is continuous. The *radula*. The rhachidian is asymmetrical and has a B5–6 seriation. The adlateral is bicuspid, or so I think we may regard it, the inner angle being produced upwards to form a prominent point. The ectocone is very high and acute. There is a vestigial entocone on the second lateral.

The main cusp of this tooth is low and small (cusp standing to base as 32 : 80), stout and inwardly inclined. Dall (*l.c.*) erroneously states that the " endostyle " (sc. dorsal stylets) are absent.

The genitalia. (1) Male. The hectocotylus is rather large and stout. In old specimens it is remarkably hard and solid. The ligula has two prominent " cheeks," the calamus is very prominent. In both the young and the old specimen the penis has a very long tubular appendix, and a second smaller circular appendix at the point of entry of Needham's organ. I am satisfied that this is not adventitious. (2) Female. The distal part of the oviduct is very long and stout, and there is a very stout, freely projecting vaginal portion. The oviducal glands are very small and the proximal oviduct slender.

*Maximum size.**—? 311 mm. (Massy, 51 + 260).

Habits, etc.—It is described by Orbigny (*l.c.*, p. 50) as littoral and living among rocks. He also records that it eats small fishes. Lönnberg (*l.c.*, p. 49) records it as a littoral form. One of his specimens had taken possession of an empty *Voluta* shell (cf. Winckworth, *l.c.*).

Remarks.—The distribution of this form in the Indian Ocean is highly suspect. My own record (1921, p. 437) is certainly erroneous. Tryon (*l.c.*) records it from the Sandwich Islands. He does not describe the specimen beyond saying the surface is " granular with many beards," the latter characteristic being inapplicable to our species. Joubin mentions a specimen from the Indian Ocean without description, and Winckworth (*l.c.*) records it from Ceylon. The particulars given are not such as would incline one to believe these authors are dealing with *J. fontaniana*. One of Winckworth's specimens has arms decreasing markedly and regularly from the ventral to the dorsal pair. It also has a long, narrow body. On the whole, then, I think we can rule out these Indian Ocean and C. Pacific records or at least express a strong suspicion concerning them.

Massy's record from Natal (*l.c.*) is doubtful, but a little more plausible. Nevertheless, we should note the following differences : (1) The arms are more unequal in size than in any of our specimens or Orbigny's, the disparity attaining 26% of the longest arm; (2) the maximum arm-length is about 83%, *i.e.* much longer than any of our specimens and far longer than in the type; (3) there is a marked inequality in the web, giving a disparity index of 56%, and (4) the funnel is about $\frac{7}{9}$ the length of the web. In Orbigny's specimen it is shorter ($\frac{1}{2}$ the web-length) and in specimens in the British Museum it is shorter still.

In all I think Massy may have had a well-marked local variety to which I give the name :—

Joubinia fontaniana, var. **africana,**

differing from the S. American form in the characters enumerated above.

All the specimens I have examined exhibit the characters enumerated by Orbigny in his description. The squat, broad body, short arms, even and rather low web, tuberculate skin are regularly associated, and the Magellanic specimens seem to be very homogeneous.

* One of Winckworth's specimens was 60 mm. in mantle-length.

Joubinia campbelli (Smith).

(Text-figs. 73–74.)

Polypus campbelli, Smith (1902, p. 201); *Octopus campbelli*, Joubin (1906, p. 1). See note, p. 145.

Holotype.—In Brit. Mus.

Specimen seen.—One specimen (♂) from Campbell Is. (New Zealand). (Type.)

Distribution.—Only known from the type locality.

Structure.—The mantle is " short and purse-like " (Smith). The head is a little narrower than the body. The arms are in the order 3.2.1.4. (only one side complete) and are short, 78% of the total length. The seventh pair of suckers on the lateral arms is abruptly enlarged and has an index of 21%. Their height is also much above the average (in one

Fig. 73.—*Joubinia campbelli.* Hectocotylus. × 5·5.

Fig. 74.—*Joubinia campbelli.* Penis.

pair they are 5 mm. high). The sections of the web are subequal, the disparity index being 25%. The web is rather long, 28% of the arms. The surface is covered above and below with small, close warts and granules and resembles that of *fontaniana*. The type specimen has hardened very much during preservation, so that I hesitate before comparing the sculpture. But that of *campbelli* is rougher and more prickly than that of *fontanianus*. The colour of the preserved type is not quite as described by Smith (" dark dirty olivaceous on the dorsal surface "). The dirty olivaceous shade is present as a kind of surface-bloom over a basal reddish-brown tint.

The funnel has a very small free portion ($\frac{1}{3}$ of the total length). The locking apparatus is continuous from side to side. The funnel-organ is badly preserved, but I think it is **W**-shaped. There are probably ten filaments in each demibranch. The hectocotylus is 8·5% of the third arm. The organ is a little worn and is somewhat frayed, so that a very precise comparison with *fontaniana* is impossible. However, it does not seem to have the marked " cheeks " nor the laminae copulatoriae seen in *fontaniana*. The calamus is very well developed and is long and

slender. The edges of the ligula are very much inrolled and remind one rather of the condition seen in *Benthoctopus ergasticus* (q.v.). The penis differs from that of *fontaniana* in that the terminal part is longer and the primary appendix shorter. The second appendix is situated more or less as in *fontaniana*.

Maximum size.—120 mm. (?+).

Remarks.—Joubin (1906, p. 1) suggested that this form is nearly allied to *J. fontaniana*. With this verdict I agree. The peculiar features of the hectocotylus and penis which distinguish *fontaniana* occur in *campbelli*, and in several minor features (web and enlargement of suckers) there is a general agreement with that form. It is to be distinguished from *fontaniana* on account of differences in (1) the pallial index, (2) size of suckers, (3) depth and shape of the web and (4) form of the calamus.

Habits, etc.—Nothing is known concerning this rare species.

Genus 5. **Scaeurgus,** Troschel, 1857.

Type of the genus.—Octopus unicirrhus, Orbigny.

Definition.—Octopods with the third left arm hectocotylized, a large ligula with inrolled sides and prominent calamus. The penis has a long diverticulum. The arms and web are subequal.

In 1857 Troschel proposed this generic name for *Octopus Cocco*, Vérany, which is now recognised as the *Octopus unicirrhus* of Orbigny, and for *Sc. titanotus* (= *O. tetracirrhus*, delle Ch.). These forms are distinguished by the possession of a hectocotylus on the third left arm. In 1880 Tiberi included delle Chiaje's *tetracirrhus*, without questioning its status, in this genus, on the strength of the similar position of the hectocotylus in that species. Tryon (1879, p. 127) pointed out that the constitution of the genus is uncertain. In 1923 Naef (pp. 691, 710) expressed a strong doubt as to the propriety of retaining *unicirrhus* and *tetracirrhus* in the same genus. He was of the opinion (*a*) that *unicirrhus* and *tetracirrhus* are very unlike in general structure, and (*b*) the mere possession of a left-hand hectocotylus is not sufficient to form a common generic basis, as *O. hoylei* (Berry, 1914, right hectocotylus) is very like *tetracirrhus*. I quite agree with Naef that *unicirrhus* and *tetracirrhus* are structurally dissimilar, though I do not see that he has proved that " bei eng verwandeten Arten kann der Hektocotylus rechts oder links sein." The only instance which he adduces in support of his contention is that of *O. hoylei* and *P. tetracirrhus*, and at present, though I concede that they are very alike, we do not know enough about the anatomy of *hoylei* to assert that it belongs even to the same genus. Nevertheless, Naef's suggestion is valuable. I have made a fairly exhaustive study of the two species placed originally in *Scaeurgus*, and find very marked differences between the two forms. I retain *Scaeurgus* as the generic name for *unicirrhus* (*coccoi*) in spite of the fact that Hoyle (1910, p. 412) designated *Scaeurgus titanotus*, Troschel, as the type of the genus. Hoyle was apparently unaware of the fact that Fischer (1882, p. 334) had previously made *Octopus tetracirrhus* (*titanotus*) the type of his *Pteroctopus*. The latter genus actually does not figure in Hoyle's list. As I think it is quite clear (cf. p. 196) that Troschel's *titanotus* is delle Chiaje's *tetracirrhus*, and as it is

proposed to maintain Fischer's genus, it follows that *unicirrhus* must be regarded as the genotype of *Scaeurgus*. This genus I regard as rather closely related to *Joubinia*, but not to be identified with it. "*Scaeurgus*" *tetracirrhus* is now sundered from its former associate and placed in a separate genus, *Pteroctopus*, which is I think allied to *Macrochlaena* (cf. p. 197).

Scaeurgus unicirrhus, Orbigny.

Octopus unicirrhus, delle Chiaje (MS., 1838), Orbigny (1840, p. 70); *Octopus Cocco*, Vérany, 1846, p. 109, tav. 4); *Octopus vulgaris* (pars) Gray (1849, p. 7); *Octopus cocco, id.* (*l.c.*, p. 19), Vérany (1851, p. 22, Pl. 12, 12 bis); *Scaeurgus Coccoi*, Troschel (1857, p. 57, Pl. IV, fig. 6); *Octopus unicirrhus*, Targione Tozzetti (1869A, p. 21); *Scaeurgus coccoi*, Tryon (1879, p. 127, Pl. 39); *Scaeurgus unicirrhus*, Tiberi (1880, p. 12), Jatta (1896, p. 234, Pl. 3, 25, 26), Robson (1921, p. 435, Pl. 66, fig. 2); *Scaeurgus patagiatus*, Berry (1913, p. 564; 1914*a*, p. 305, Pl. XLVII, fig. 2; Pl. XLVIII, fig. 1), Sasaki (1920, p. 184); *Octopus* ("*Scaeurgus*") *unicirrhus*, Naef (1923, p. 713); ? *Scaeurgus* sp., Degner (1925, p. 79).

Type specimen.—Not traced.

Specimens seen. (*a*) In Brit. Mus.

Two (♂) from Naples: 98.5.21.335–6. Two (♂♀) from the Indian Ocean: 1921.9.14.266.

Distribution.—Mediterranean (Auctt.); Indian Ocean (Robson); Hawaiian Is. (Berry); Japan (Sasaki). ? Shore to 178 fathoms.

Description.—The body is broadly or narrowly oval. The head is usually a good deal narrower than the body. The mantle-aperture is rather narrow. The arms are 61–80% of the total length and more or less subequal. The suckers are very small (7–10%) and not enlarged in the male. The web is 21–29% of the arms and more or less subequal. The surface is covered uniformly with roundish warts which are sometimes multifid and tend to be arranged linearly and even to be fused into ridges, and there is usually a single cirrhus over each eye. The funnel-organ is W-shaped, sometimes VV-shaped (Naef, *l.c.*, p. 714). In one Mediterranean and one Oriental form seen by me and in Berry's *patagiatus* there is a low peripheral keel on the mantle.

Colour.—In life the upper part of the body is a clear light green passing to a paler hue with a bluish iridescence below. Vérany notes greenish-blue lines on the body and edge of the web. There are usually brownish maculations on the dorsal surface.

There are 13–14 filaments in each demibranch. The rhachidian tooth of the radula has a symmetrical seriation ($A_{3\ 4}$), the admedian is narrow and has a high cusp. The second lateral is devoid of an ectocone. The ink sac is normal and imbedded in the liver, though its duct is largely free. The hectocotylized arm is markedly shorter than its fellow. The ligula is long (8–10%). It has heavily infolded sides and its surface bears a number of weak laminae. The calamus is long, pointed and supplied with well-developed cheeks. The penis has a long diverticle; but the male genitalia are otherwise like those of *O. vulgaris*.

Maximum size.—227 mm. (Brit. Mus.).

Habits.—According to Jatta this is a littoral form, found on muddy bottoms down to 50 m. Berry records it as deep as 178 fathoms. Degner (1925, p. 79) records young pelagic "*Scaeurgus*" from 300–65 m. in the Mediterranean. For a discussion of these see *Macrotritopus* (p. 168).

Remarks.—Orbigny published this name as that of an "uncertain species" after a MS. account of delle Chiaje, giving certain features by which it can be distinguished from *tetracirrhus*. Vérany published a full account with recognizable figures under the name of *O. cocco*, though he cites "*unicirrhus*, Férussac," in his synonymy. Orbigny's description leaves something to be desired, but it may be said to be recognizable and must obviously have priority over Vérany's *cocco*.

This form differs from any species of *Octopus* (s.s.) in the following characters: (1) The large and highly characteristic hectocotylus, (2) the long diverticulum of the penis. These features coupled with the even web and subequal arms suggest affinity with *Joubinia*, from which, however, it differs in not possessing a second diverticle, as well as in sundry secondary features. On re-examining the specimens from the Indian Ocean obtained by the "Sealark" in 1921 (Brit. Mus., 1921.9.14.266) and the data for Berry's *patagiatus*, I am confident that they are all referable to this species. The former are rather longer in the arms than usual. On the table on p. 54 some of Berry's data for *patagiatus* are given and may be compared with other data. The differences are insignificant, except for the size of the arms. The peculiarities of colour, funnel-organ, hectocotylus and the presence of a lateral pallial fold and linear fusion of the dorsal tubercles are all characters shared in common. At the same time it should be pointed out that in Berry's specimen one sucker is definitely larger than the rest in the male, a feature not found in the forms I have seen.*

Genus 6. **Macrochlaena,** new genus.

Type of the genus.—Octopus winckworthi, Robson, 1926.

The mantle and head are long and narrow. The arms and web are subequal, the arms being very short (only about half the total length) and the web deep. The funnel-organ is paired, and the funnel has no freely protruding part. The second lateral tooth of the radula has a median mesocone, and the male reproductive organs have no "appendix." The inner demibranch is reduced.

Octopus winckworthi presents so many peculiar divergences from the main *Octopus*-like stock that it cannot be left in that genus. The only available specimen exhibits some singular features, the significance of which it is not easy to interpret. The deep web, short arms and double funnel-organ ally it with *Bathypolypus*, a similarity enhanced by the gelatinous body and somewhat reduced gills. I am not inclined to lay much stress on this resemblance, as the ink sac is present and well developed. The animal, however, is so unlike the normal littoral Octopods that one suspects some difference of habitat, *e.g.* it may be specially adapted for burrowing in mud.

* Troschel (*l.c.*, p. 51) states that calcareous epidermal scales are found in his *Sc. titanotus* (= *tetracirrhus*). I have found such scales in some (not all) examples of *Sc. unicirrhus* (see p. 197).

Macrochlaena winckworthi (Robson).

(Text-figs. 75–76.)

Octopus winckworthi, Robson (1926, p. 161, figs. 1–6).

Holotype.—In Brit. Mus.

Distribution.—Only known from the type locality, Tuticorin (probably from pearl oyster beds in about 8–11 fathoms).

Specimens seen.—In Brit. Mus.

One specimen (♂) from Tuticorin : 1925.11.23.1. (Type.)

Description.—The animal is very slender and compact. The build has almost the stream-lines of a squid. The body is narrow, its width being about 48% of the length. The head is as wide as the body and the eyes are small. The mantle-aperture is moderate (B). The arms are subequal, the third apparently being a little longer than the rest. They constitute the very moderate proportion of 53% of the total length. The suckers are of moderate size (about 12%) and are not especially enlarged. The web is more or less equal all round and very deep, about 33% of the arms. The funnel is very short and much involved in the tissues of the head, so that it has scarcely any free part. The funnel-organ is double, its limbs curved and thick. The adhesive mechanism is very well developed, the cephalic ridges being very prominent, and I believe that greater locomotor activity than usual is indicated herein. There are 9 filaments in each demibranch ; the inner demibranch of each gill is very much reduced (cf. Robson, *l.c.*, fig. 4). The rhachidian tooth has a symmetrical A_3 seriation. The first lateral is long and has a low cusp. The second lateral is very singular, as its cusp is median, a quite unique position in the genus. The marginals, are well developed and are long and cone-shaped. The ink sac is well developed. The penis has a small diverticulum, and there is no appendix penis. The spermatic glands are undifferentiated. The hectocotylus is either incompletely developed or very simple in structure. The ligula is undifferentiated and the calamus is very weak.

Fig. 75.—*Macrochlaena winckworthi*. Male reproductive organs. × 3·6.

Maximum size.—93 mm.

Remarks.—The single specimen representing this curious form seems at first sight to be immature. The hectocotylus is singularly undeveloped, the calamus and the ligula being but little differentiated. The " spermatic glands " are also very undeveloped. The depth of the web and arms and the shortness of the latter might also incline one to suspect that the animal is sexually immature. Nevertheless, the testis is large and well developed (very much larger than that of the half-grown *O. vulgaris* figured by Marchand (1907, p. 359)), the spermatophores are fully formed,

and the rest of the organs (reproductive and others) have not the appearance of immaturity. On the whole I am forced to conclude that the animal is sexually mature. That being the case, the very slight differentiation of the hectocotylus and spermatic glands is remarkable. It is possible, of course, that they are undergoing some seasonal change. If they are not, we must conclude that their moderate development is a feature of the genus.

Fig. 76.—*Macrochlaena winckworthi*. Penis.

From the only data available, this would appear to be a littoral form. Nevertheless, as already stated, there are many points of resemblance to the Bathypolypodinae. Further knowledge of the habits of this animal are desirable. The resemblances to the Bathypolypodinae may be due to its occupying muddy habitats. This habit, as suggested by me (1926, p. 1356) is associated perhaps with certain *Bathypolypus*-like modifications in *Pteroctopus tetracirrhus*.

Genus 7. **Pteroctopus,** Fischer, 1882.

Type of the genus.—Octopus tetracirrhus, delle Chiaje.

Octopods with normally developed ink sac, which is free from or only slightly involved in the liver. The funnel-organ is double. The web is very deep, and the suckers are minute. The hectocotylus is on the third left arm, and is simple with a small calamus.

In 1882 Fischer thus defined his genus, for which he cited the so-called *Scaeurgus tetracirrhus* as the only existing species: " corps bursiforme, sans nageoires latérales; bras réunis par une membrane très large, prolongée jusqu'à l'extrémité des bras." I consider Fischer was correct in placing *Scaeurgus tetracirrhus* and *unicirrhus* in different genera; although the grounds for assigning *tetracirrhus* a separate generic position which are embodied in his definition, are wholly inadequate and disregard its essential peculiarities. I agree with Naef that the position of the hectocotylus alone cannot be allowed to be of paramount importance in determining the affinity of these forms. How distinct *unicirrhus* and *tetracirrhus* are generically may be seen in the character of (1) the hectocotylus, (2) male generative organs.

For the affinity of this form see p. 33. I do not include here Berry's *Octopus hoylei* (Naef (1923, p. 691)). It is practically impossible to decide the correct position of that form without fuller information, and it differs from *P. tetracirrhus* in several important respects.

Pteroctopus tetracirrhus (delle Chiaje).

Octopus tetracirrhus, delle Chiaje (? 1830, Pl. 72 *), Orbigny (1840, p. 36), delle Chiaje (1841, p. 4; 1841*a*, p. 65), Vérany (1851, p. 25, Pls. VII and VII bis); (?) *Scaeurgus titanotus,* Troschel (1857, p. 51, Pl. IV, figs. 4–5), Tryon (1879, p. 119, Pl. 27, fig. 17); *Scaeurgus tetracirrhus,* Tiberi (1880,

* This plate was not published with the text. It was, however, on sale at least by 1836 and was re-issued (1841, as Pl. 4).

p. 12), *Pteroctopus tetracirrhus*, Fischer (1882, p. 334); *Scaeurgus tetracirrhus*, Jatta (1896, p. 230, Pls. 5, 25), Lo Bianco (1903, p. 170); Joubin (1900, p. 36); *Octopus* ("*Scaeurgus*") *tetracirrhus*, Naef (1923, p. 710).

Specimens seen.—In Brit. Mus.

One (♂) Naples: 1912.8.21.9. One (♂) unknown locality: 1879.1.20.3. Two (♂♀) unknown locality: 1895.5.21.331.

Type specimen.—Not traced.

Distribution.—Mediterranean–Atlantic (50–599 m.).

Description.—The body is broadly ovoid, the head being distinctly narrower than the body. The mantle-aperture is very narrow (B–A). The arms, as Naef says, are never seen intact; but they appear to be subequal in length and about 78% of the total length. The suckers are very small (5–5·8%) and usually deeply imbedded in the swollen skin. The web usually has the formula A.B.C.D.E., and is 34–39% of the arms in depth. The skin is always swollen and highly gelatinous. This is so often recorded that I feel it is not due to bad preservation. The skin is always covered with low, rather closely set tubercles and there are usually two cirrhi over each eye. According to Jatta the living animal is yellow in colour with a greenish iridescence on the ventral surface. Vérany states that it tends to a reddish hue.

The funnel-organ consists of two rather slender V-shaped pieces. There are 9–10 filaments in each demibranch. The radula has a rhachidian with symmetrical seriation (A_3); the first lateral has a high cusp and wide base; the second lateral has neither "heel" nor entocone. Jatta (*l.c.*, Pl. XXV, fig. 7) shows square marginal plates, an interesting feature if constant. Unfortunately I have never obtained a satisfactory preparation of the marginals. The ink sac in the three individuals which I have examined was either entirely free of the liver or only slightly involved in the outer tissue of the latter.

The third arm on the left side is hectocotylized. The end organ is short, 3–4% of the arm. It has a rather broad conical ligula with faint groove and laminae, and a small basal calamus. The penis has a rather long distal part and a short, recurved and rather bulky diverticle. The dorsal stylets are of the normal Octopod form (Jatta).

Maximum size.—280 mm. (Jatta).

Habits.—Vérany thought that this form probably lived in mud. Jatta states that it lives in coralline deposits and mud at depths between 50–100 metres. It is evidently rare both in the Gulf of Naples and off Genoa. It was obtained in 599 metres by the "Princesse Alice" (Joubin, *l.c.*). The post-embryonic young are evidently pelagic (cf. Lo Bianco, 1903; see, too, *Scaeurgus*, p. 193).

Octopus tetracirrhus, though poorly described by delle Chiaje, is sufficiently recognizable by its shape, colour, and deep web, features which are again apparent in Vérany's drawing of the type (*l.c.*, Pl. 7), and the form portrayed by those authors and Orbigny is manifestly the deep-webbed form with sinistral hectocotylus and small ligula found in the Mediterranean to-day. Troschel's *titanotus* must be synonymous with this form, as it has a sinistral hectocotylus and a short open ligula and cannot be confused with *unicirrhus*. The arms are shorter than I have

usually found in this form. Jatta (*l.c.*), however, gives the typical length as short. I am as yet a little uncertain if the length of the arms is of diagnostic value as between *tetracirrhus* and *unicirrhus*.

This form is clearly very unlike *Scaeurgus unicirrhus*, with which it has been associated. The funnel-organ, hectocotylus and penis differentiate it at once from that form. At the same time it is clearly unlike the members of *Octopus* (s.s.). The character of the funnel-organ, mantle-aperture and locking apparatus and the gelatinous skin remind one of those structures in *Macrochlaena*, an impression confirmed by the short arms, small suckers and deep web. The gill and radula do not resemble those of *Macrochlaena*. However, I believe that these forms are nearly allied. I can find no traces of the layer of calcereous granules found in the skin and described at length by Troschel (see p. 193). It is likely that the latter was dealing with a pathological specimen. As pointed out elsewhere (p. 195) the resemblance between this genus, *Macrochlaena* and *Bathypolypus* may be due to their living on muddy bottoms (cf. Robson, 1926, p. 1356).

Genus 8. **Paroctopus,** Naef, 1923 (**Pseudoctopus,** Grimpe, 1925).

Type of the genus.—*Octopus digueti*, Perrier & Rochebrune (by designation [Naef, 1923]).

Definition.—Littoral Octopodines which usually deposit large eggs (up to 10 mm. long). The hectocotylus in the adult is long and usually narrow, and is 7–20% of the arm in length. The arms are rather short (but not invariably so), and the body is squat and bursiform.

I am rather sceptical as to the importance of the character which Naef used to distinguish this genus. It was proposed by him (*l.c.*, p. 692) for *Octopus digueti*, Perrier & Rochebrune, the eggs of which are unlike those of such other forms as are known, inasmuch as they are deposited separately and affixed by long stalks to the substratum and are much longer (as much as 9–10 mm.) than is usual in *Octopus*. Extremely little is known about the oviposition and size of eggs in the subfamily, so that we do not know the value of the latter character as a systematic criterion. I include here *Octopus hongkongensis* and *Octopus apollyon*. The eggs of the latter seem from Tryon's figure (1879, Pl. 19, fig. 3) to be large * and like those of *Octopus digueti*, though they are not deposited separately. Moreover, the latter and *apollyon* are very much alike in general structure. *O. hongkongensis* is included here on account of its very close resemblance to *apollyon*, though nothing is known of the eggs. These two forms agree in having a long, pointed and narrow hectocotylus, that of *digueti* being likewise long and pointed, though it is wider and more spatulate. I think *Octopus gilbertianus* and *Octopus californicus* are possibly referable to this genus (see Berry, 1912, pp. 284 and 286). The latter form, however, has a double funnel-organ.

Paroctopus digueti, Perrier & Rochebrune.

(Text-figs. 77–79.)

Octopus digueti, Perrier & Rochebrune (1894, p. 770), Rochebrune (1896, p. 77, Pl. 1), Naef (1923, p. 692).

* But cf. p. 203.

Type specimen.—In N.H.M., Paris (sc. Nos. 33–92).

Specimens seen.—In N.H.M., Paris.

Three (♀♀♀), one (♂) from Lower California (including type ?).

Distribution.—Only known from Lower California ("Golfe de Californie" (Rochebrune).

Description.—The body is bursiform and short and the head is defined by a well-marked constriction. The eyes are very small. The arms

Fig. 77.—*Paroctopus digueti.* Funnel-organ.

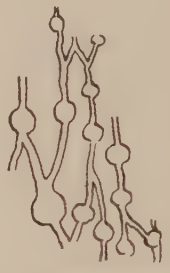


Fig. 78.—*Paroctopus digueti.* Pallial sculpture. (Diagrammatic.)

are subequal and are about 70–75% of the total length. The suckers are small (8%), but one is enlarged in the male (about 23%). The web is of the shape D.C. = E.A. = B. and is fairly deep (24% of the arms). The funnel-organ is of the highly characteristic type seen in *Octopus apollyon*, *i.e.* each base formed of the meeting of the median and outer limbs is long and the two median limbs are nearly vertical. The inner edges of the two bases are closely apposed. The organ differs from that of *apollyon* in that the outer arms are more slender and the apex of the median piece is pointed, not dome-shaped. The hectocotylus is 7·8% of the arm. It is elongate and pointed, and the calamus is placed about one-third of the distance from the base. The ligula is deeply excavated and has a distinct midrib and faintly marked laminae.

Fig. 79.—*Paroctopus digueti.* Hectocotylus. (Type.) ×7.

The surface is either entirely granular or ornamented by small granules situated on anastomosing lines. The ground-colour (in alcohol) is yellowish and maculated, reticulated or uniformly covered with purple pigment. The eggs, which are deposited in the valves of Lamellibranchia, are unlike those of such other Octopoda as are known, in that they are very large and deposited separately. Rochebrune, in his full description, does not say if Diguet or any observer specifically informed him that the eggs of this species are found only in Lamellibranch shells. At present we only know that all the preserved eggs are so deposited, and that of the six adult specimens in the Natural History Museum, Paris, three are concealed in the empty shells of *Cytherea squalida* and *Pecten dentatus*. One, however, (47, 1898) has made its

home in a broken bottle (G.C.R. MS.). The eggs are elongate-elliptic in shape and measure 9–10 × 3–3·5 mm. They are thus much larger than, *e.g.*, those of *Octopus vulgaris*, and resemble those of *Eledone*. Each egg is anchored down by a terminal filament about 3–4 mm. long, which at its point of attachment to the substrate forms a circular or oval plate of a dark colour. The eggs are usually grouped in sets of 2–5. This again is in contrast to the usual mode of deposition, which is in grape-like clusters.

Maximum size.—116 mm. (±), Natural History Museum, Paris (♀).

Remarks.—This remarkable form requires further study. One would like to know if the eggs are exclusively laid in Lamellibranch shells. I do not think there is any doubt but that this form is, as Rochebrune says (*l.c.*, p. 78), very like *Octopus apollyon*. As all the known examples are small they might be taken for young forms of the latter. The smallest individual of that species measured by Berry (1912*a*, p. 282), however, had arms 78% of the total length (No. 134). The funnel-organ differs in detail and the hectocotylus and place of oviposition are similarly different.

Paroctopus hongkongensis, Hoyle.

(Text-figs. 80–81.)

? "*Octopus punctatus*, Gabb," Dall (1884, p. 341); *Octopus hongkongensis*, Hoyle (1885, p. 224); *Octopus punctatus* Gabb, Hoyle (1886, p. 100, in error); *Octopus hongkongensis*, *id.* (*ib.*, Pl. V, title); *Octopus punctatus*, Ortmann (1888, p. 662); Joubin (1897; p. 110, Pl. IX), *id.* (1897*a*, p. 98); *Polypus punctatus*, Wülker (1910, p. 7); *Polypus hongkongensis*, Berry (1912*a*, p. 280 ? part), *id.* (1912*b*, p. 391); Massy (1916A, p. 197), Sasaki (1920, p. 177); *Octopus hongkongensis*, Winckworth (1926, p. 326), Channappayya (1927, p. 109).

Holotype.—In Brit Mus.

Specimens seen.

(*a*) In Brit. Mus.

One (♂) from Inoshima Island, Japan : 89.4.24.45.

(*b*) In U.M., Leipzig.

One (♂) from Japan.

Distribution.—Kamschatka (Joubin, ? Dall); Hong Kong (Hoyle); Inoshima Islands, Japan (Hoyle, in 345 fathoms); Aburatsubo (Wülker); Andaman Sea and S. of Ceylon, in 90–132 fathoms (Massy); Aleutian Isles -Korea, in 45–437 fathoms (Sasaki); Lake Tamblegam and Venkali Reef, Ceylon (Winckworth); Gulf of Manaar (Channappayya).

Description.—The following description is based very largely on the type of Hoyle's species, but it is supplemented by the information given by Joubin on the hectocotylus, suckers and arms and the Leipzig specimen. For other data see table of measurements (p. 54).

The mantle is as broad as it is long, the head being considerably narrower than the body. The arms are in the order 1.2.3.4. (L.), 2.1.4.3. (R.), and are 75–85% of the total length. The suckers attain a maximum diameter of 13% of the mantle. They are not very abruptly enlarged in the type, but the 20–22nd pair are excessively large in Joubin's specimen.

The web has the formula B = C = D.A.E., and is about 23% of the arms in depth. The surface is covered with numerous, rather small, simple tubercles and short irregular wrinkles, and there are two cirrhi over each eye. The type specimen is very much discoloured, but was apparently brownish-purple. The mantle-aperture is moderate in width (B). The funnel-organ is of a simple **W**-shape (in the Leipzig specimen it is like that of *apollyon*), the median and lateral limbs being

Fig. 80.—*Paroctopus hongkongensis*. Radula. (Type.)

narrow and symmetrical. There are 10 filaments in each demibranch. The radula has a rhachidian with an A_4 seriation. There seems to be a "lag" on one side. The basal plate of the first lateral is very long and thin. The second lateral has a marked heel, but no ectocone. The third lateral has a narrow base, and the blade is more or less straight. The hectocotylized arm is noticeably shorter than its fellow. Its ligula is rather like that of a specimen from Alaska figured by Berry (1912, Pl. XXXIX, fig. 4), but it differs in sundry minor details. The figure given by Hoyle (1886, Pl. V, fig. 4) does not at all resemble that of the actual specimen, as the calamus is far more open in the former. It is possible that the specimen has contracted. The ligula is 11% of the arm. The specimen from Kamschatka figured and described by Joubin (1897*b*) is somewhat puzzling. It is referred to "*punctatus*" by Joubin with much hesitation, and I am inclined to think that the bad state of its preservation puts it out of court as evidence. The suckers, hectocotylus and skin alone are described. The suckers are excessively large and abruptly enlarged at the 20–22nd pair. This is not found in the type. The hectocotylus is enormous, being about 20% of the arm in length. It is, however, of the same general type as that of *hongkongensis*. The skin is finely granular, but is not described in detail. The specimen seems to represent an extreme phase of *hongkongensis*. I am not certain as to the status of Massy's specimens (1916, p. 197). The single adult is a female and Massy does not give very exhaustive details, so that one cannot make a critical estimate of its position. The arms are short (75%) and in the order 3.4 = 2.1., 3.2.1.?, which are features more like those of *apollyon*. These specimens may go a long way towards bridging the gap between *apollyon* and *hongkongensis*. Wülker's specimen is not described in detail.

Fig. 81.—*Paroctopus hongkongensis*. Hectocotylus. × 1·6.

Maximum size.—If Joubin's Kamschatkan specimen is really referable to this species it must have been about 1232 mm. in total length. The great Aleutian specimens noted by Dall may or may not belong to this species.

Remarks.—The question of the status of this species and *apollyon* is discussed on p. 204 and below. I confine myself here to a description of the type of *hongkongensis* and other specimens which may be attributed to it and a summary of the relation between *apollyon* and this species. Hoyle's earlier name (1885) must stand for the Japanese species, even if the Kamschatkan specimen from Avatcha recorded as *punctatus* without description by Dall in 1884 be ultimately referred to *hongkongensis*. Gabb's earlier name cannot be accepted as applicable to Hoyle's species, as it is preoccupied (*v.* p. 202).

The relation between *Octopus hongkongensis*, Hoyle, and *Octopus apollyon*, Berry.

Our information consists of (*a*) for *apollyon*, the full data of Verrill (1883) and Berry (1912–13); (*b*) for *hongkongensis* the descriptions of Hoyle (1886) and Massy (1916), and less complete data supplied by Wülker, Joubin and Sasaki (*q.v.*). Actually, Hoyle's description of the latter species is the only complete one, and is supplemented here by additional observations on the type. It therefore follows that we must largely speak of *hongkongensis* in terms of the type specimen. The differences between this and *apollyon* are as follows :—

	Arm formula.	Arms % total length.	Hecto-cotylus.	Funnel-organ.	Mantle-width.
Hongkongensis	1.2.3.4. 2.1.4.3.	85	11% of 3R	Simple W, limbs thin.	100
Apollyon (Berry) (8 specimens)	2.3.1.4. 2.1.3.4. etc.	70–78	11–2·8%	Limbs thick, bases straight.	52–79–100*

The radula of *hongkongensis* also differs markedly from that of *apollyon* as figured by Dall, but not from a specimen of *apollyon* from Vancouver and another from San Pedro, California. The general form of the hecto-cotylus is alike, and these organs only differ in size. The penis is very similar. There seem to be some possible difference in vertical range, as *apollyon* is always littoral and *hongkongensis* ranges from 90 (? shallower, cf. Winckworth) to 437 fathoms. Massy's *hongkongensis* (♀) from the Indian Ocean has much shorter arms and a less globular body, and therefore approaches *apollyon* in these respects. Unfortunately the other critical characters are not mentioned. Joubin's specimen from Kamschatka has an enormous ligula, much longer than that of the type of *hongkongensis*, and very much larger suckers. It may be an old male with exaggerated (gerontic) growth-features, or it may be a local form of Wülker and Sasaki's Japanese race; only a very few details are given. There is a highly interesting form in the University Museum, Leipzig, labelled " Japan," which has the following characters :—

* See discussion on Measurements.

Mantle, width index.	Head.	Arms.	Arms, index.	Web, formula.	Index.	Suckers.	Ligula.
72	56	1.2.3.4 1.2.4.3(♂)	82	C = D = B.A.E.	26	10%	13%

The funnel-organ is shaped like that of *apollyon* as figured by Berry (1913, fig. 1). The skin is covered with rather sparse granules. Over the eyes are numerous small tubercles, and there is one large cirrhus at the posterior edge of the eye. The colour is brownish-purple. The penis is, however, very unlike that of either *hongkongensis* or *apollyon*, as it is reniform. This form, therefore, while like *hongkongensis* in its arm-length, web, and ligula, resembles *apollyon* in body-shape and funnel-organ. The penis is peculiar and unlike that of neither of the two species. I think this specimen serves to show how heterogeneous the *hongkongensis* population is, and how yet another character, the shape of the funnel-organ, is shared in common by it and *apollyon*.

We can only conclude that there is a great deal of community between the N.W. and N.E. Pacific members of this group, and that, while individuals of extremely different type occur, we do not know enough of the Japanese forms to justify a final verdict as to their specific status.

Paroctopus apollyon, Berry.

(Text-fig. 82.)

Octopus punctatus, Gabb (1862, p. 170, preocc. (Blainville, 1826, p. 195)), Carpenter (1864, pp. 613, 632, 664), Dall (1866, p. 243, fig. 27), ? Cooper (1870, p. 70), Dall (1873, p. 484), Verrill (1880*a*, p. 252), *id.* (1883*a*, p. 117), Dall (1884, p. 341), Orcutt (1885, p. 535); *Octopus punctatus*, Keep, (1888, p. 215), Williamson (1892, p. 217), Taylor (1895, p. 98), Kelsey, (1907, p. 45 (not seen)), Baily (1907, p. 93), Duges (1907, p. 337); *Polypus hongkongensis*, Berry (1911*a*, p. 302), *id.* (1912*a*, p. 280, Pl. XXXV, fig. 3; Pl. XXXVI, fig. 1; Pl. XXXIX, figs. 3–4; Pl. XL, fig. 1, ? pars); ? *Polypus apollyon*, *id.* (*l.c.*, p. 284), *id.* (1913 p. 72); *Octopus punctatus*, Contreras (1917, p. 123); ? *Polypus hongkongensis*, Sasaki (1920, p. 177); *Polypus apollyon*, Fisher (1923, p. 147); *Octopus punctatus*, Robson (1925, p. 106).

Holotype (of "*punctatus*," Gabb) destroyed (Berry, 1912*a*, p. 284).

Specimens seen.—In Brit. Mus.

One (♂) from Vancouver Island: 60.2.29.3. One (♀) from Esquimault Harbour: 68.6.29.11.

Distribution.—? Kamschatka (Dall); Alaska–Lower California (detailed distribution in Berry, 1912*a*, p. 283); Mexico (Contreras).

Description.—The following description is based on the data of Berry and Verrill for W. American forms. The variation of this species and its relation to *hongkongensis* are set forth on pp. 201, 204. The radula of the type of *hongkongensis* differs markedly from that figured by Dall (1866, p. 243), but preparations of other Californian specimens are very like the Japanese form. This fact, as well as the very marked amount of variation noted in the material of which Berry gives data, must prepare us to suspect that Berry's later doubts concerning the homogeneity of the Californian population may be well-founded ("it seems fairly doubtful

whether all the specimens included with the type of this species . . . are in reality conspecific with one another," *id.*, 1913, p. 72).

The body is " pyriform to subglobose " (Berry). The latter states that the length and breadth are about the same. But actually his " tip of body to base of dorsal arm " measurement is always in excess of the " width of body " (*l.c.*, p. 282). The head is narrower than the body and there is a slight " neck." The eyes are " fairly prominent." The arms are usually subequal; but, as usual, they vary considerably in length, 2.1.3.4. being the most common order. They attain an average length of about 75% of the total length. In some of the smaller males from southern stations (? not from northern) the suckers are considerably enlarged at the level of the edge of the web. The exact form of the web is not given by Berry, but is D.C = B.A.E. or E.A in Verrill's specimens, and in Berry's it is highest laterally and shortest in sector 4–4. It probably attains a maximum depth of about 25% of the arms. The entire surface is covered with " numerous papilliform tubercles with stellate bases " and much interrupted " longitudinal wrinkles." Over each eye are 2–3 cirrhi, of which one is large and erect. There are in addition a series of bilaterally arranged cirrhi on the arms, web, and body. Such cirrhi are very variable in their size. Some specimens are almost entirely smooth. The mantle-aperture is of moderate width (B). The funnel is free for half its length. The funnel-organ (Berry, 1913, p. 72) is W-shaped, but very peculiar, the junction of the median limbs and the lateral being not angular as usual but square. The radula is described by Dall (1866). I do not know if we can accept his figure at its face-value. It shows a symmetrical, " occasionally irregular," rhachidian, an admedian with a central and very high cusp, a second lateral with no heel and no entocone, and very heavy third laterals and cusped (!) marginals. On the other hand, the radula of an undoubted *apollyon* from Vancouver (British Museum) and another preparation from the Gwatkin collection (No. 26836) are very like that of the type specimen of *hongkongensis*, differing only in minor details. The differences between these three radulae are very curious. The difficulty is, of course, increased by our not knowing the other characters of Dall's specimen. Possibly he was mistaken in his identification. It is very noteworthy that Dall figures a *cusp-bearing marginal plate*. This is, of course, unique in the group and, if accurate, may serve to suggest that the marginal plates are derived from cusped teeth. The hectocotylized arm is much shorter and stouter than its fellow. The ligula is long. Berry's measurements (*l.c.*, p. 281) of the ligulae of thirteen specimens range from 11–2·8% of the arm. The ligula is finely pointed and its sides are inrolled to form a narrow and deep furrow, in which are visible a number of laminae copulatoriae. The eggs according to Tryon (1879, Pl. 19, fig. 3) are long and shaped like those of *P. digueti*. In the figure they are shown attached in a solid object, which may be a central rhachis (in which case the method of deposition would be like that of *Octopus* (s.s.)), or a foreign body.*

Fig. 82.—*Paroctopus apollyon*. Penis. × 2·5.

* The enigmatic form described by Fisher (*l.c.*) deposited its eggs in clusters. Their size is not given, but they look very small.

Variation.—The problem of variation in this species is involved in the question of its relationships with the other N. and N.W. Pacific forms, and until more material is forthcoming it is impossible to discuss this question with profit. Among the members of the Californian population as discussed by Berry, if they actually belong to the same species, the colour and sculpture are as usual very variable. Berry notes that smooth specimens occur. The size of the ligula varies from 11% of 3R to 2·8%, and thus in its extreme form comes very near that of *hongkongensis*. The length of the arms is more constant. The form of the mantle varies from a globose type to one which is almost ovoid.

Habits, etc.—The records tabulated by Berry (*l.c.*, p. 283) show that this is a definitely littoral form. Of 19 records for which exact depths are given none exceed 134 fathoms, and most of the others are entered as "shore." It appears quite definitely to prefer rocky places. Nothing else is recorded of its habits. It is eaten by the natives in California (Keep) and, if the identity of the Mexican species is correctly established, in Mexico also (Contreras).

Maximum size.—Dall (1873) states that specimens found at Sitka have "a radial spread of nearly 28 feet." 1207 mm. (Verrill, No. 62).

Remarks.—The nomenclature, variation and other problems relating to this species have been discussed by Berry (1912*a*). The name *punctatus* originally proposed by Gabb was used in 1826 by Blainville for a very imperfectly described form from the Mediterranean, probably referable to *Argonauta* or, according to Orbigny, *Ocythoe*. The name *punctatus* enjoyed a long popularity among American naturalists, but we have no option but to adopt Berry's suggestion and to apply to the species the very appropriate name he suggests. For many years now the identity of the large Octopods of the N.E. and N.W. Pacific littoral has been subject to much uncertainty. The common N.E. littoral form was recognized in 1862 by Gabb under the name of *Octopus punctatus*. In 1885 Hoyle described a large and somewhat different form from Japan as *Octopus hongkongensis*. The next year, however, he expressed himself as satisfied that this form and Gabb's species were identical. In 1912 in discussing these forms Berry somewhat doubtfully followed Hoyle's example. He suggested, however, that "the two forms are in reality distinct" (*l.c.*, p. 284), and thought that "if the Japanese specimens are typically like Hoyle's 'Challenger' specimen they should be treated as a distinct species or subspecies." He suggested the name *apollyon* for the W. American form. By 1913 he was evidently convinced of their distinctness, for he used the name at first tentatively suggested for the Californian form. A study of the type of Hoyle's species and a survey of the data has convinced me that his view is right. The two species in their extreme phases are very distinct, and are regionally and probably habitudinally separate. Nevertheless, there is evidently a good deal of resemblance between them, and in particular it is not easy at present to decide the status of the Kamschatkan and Alaskan forms nor of Massy's specimens of *hongkongensis* from the Andaman Sea and Ceylon, which differ markedly from the type specimen in two respects.

Paroctopus conispadiceus (Sasaki).

Polypus conispadiceus, Sasaki (1917, p. 367), *id.* (1920, p. 176).

Syntype.—In the Agricultural College, Sapporo.

Specimen seen.—One (♂) from off Cape Tsinka, Japan (U.S.N.M., 332986 [? 323986]).

Distribution.—Tsugaru Strait, Japan, in 47 fathoms; also obtained in Sapporo Market.

Description.—The form of the visceral sac of the type is not stated and cannot be inferred from Sasaki's description. The head is from about one-half to two-thirds as wide as the body. The arms are subequal in length, except the fourth pair which is a little shorter than the others, the second being somewhat larger than the rest. The longest are 79–75% of the total length. The suckers according to Sasaki's second description (1920) seem to be specially enlarged between the 9–12th pair, but this is not seen in the Cape Tsinka form. The suckers are 15% of the mantle-length in the male. The surface is quite smooth, except on the head, where there are a few warts and a cirrhus over each eye. The funnel-organ is stated to be VV-shaped by Sasaki. The organ of the Cape Tsinka specimen is rather damaged. The gills have 10–12 filaments in each demibranch. The hectocotylized arm is one-third shorter than its fellow, the ligula being very large, 20–12% of the arm in length. It has a basal calamus and is " typically conical, thick at base with a deep, but narrow longitudinal groove." The penis is subfusiform, and " Needham's sac joins it in front of the middle " (? long appendix). The spermatophores are on an average over half as long as the mantle. Sasaki does not comment on a very remarkable feature of this species, viz. that not only is the ink sac very small (about 15 mm. long) and not composed of a duct and reservoir but is a single sausage-shaped structure, but it seems not to be imbedded in the liver and to be quite free of the latter. The ripe ovarial ova are very long, viz. 30 mm. (Sasaki, 1917).

Maximum size.—1 metre (Sasaki, 1917).

Remarks.—The hectocotylus is very reminiscent of that of *Octopus hongkongensis*, and the species is not unlike that form. Sasaki's statement that the funnel-organ is double requires reinvestigation. That of the Cape Tsinka specimen seems to be double; but it has been damaged. The question of the size and position of the ink sac also require study. These features point to Bathypolypoid relationships. The size and form of the hectocotylus and the size of the ovarial eggs (as described by Sasaki, *l.c.*) render it inevitable that this species should be placed in *Paroctopus*. The size of the eggs is very large and almost attains the enormous dimensions of those of *Nautilus* (as described by Willey). See, however, discussion (p. 197).

Paroctopus yendoi (Sasaki).

(Text-fig. 82*a*.)

Polypus yendoi, Sasaki (1920, p. 179, Pl. 24, fig. 2).

Holotype—In U.S.N.M., Washington.

Specimens seen.—One (♂) from Cape Clonard, Korea (U.S.N.M., 332987).

Distribution.—Korea, Kinkasan, Oki Ids. (Japan) in 70—150 fathoms.

Description.—The mantle is about as broad as it is long and the periphery is bordered by a distinct horizontal ridge (? in all the specimens). The head is "only a little narrower than the body." In the type the subocular constriction is more marked than the supraocular, though the profile evidently varies (see fig. 82*a*).

In the type the arms are subequal and have the formula 1.2.3. = 4., the longest being 80–82% of the total length. The suckers are not enlarged in the male and are 10% of the mantle-length. The web is "well-developed." In the type specimen it has the rather uncommon feature of being deepest in sector E; but this condition is not found in No. 332987 (U.S.N.M.). The dorsal surface is "sparsely beset with well-marked, roundish warts of various sizes," which are most plentiful above and behind the eyes. There are no ocular cirrhi. The colour of the type is not mentioned; that of No. 332987 is pale brownish-buff. The mantle-aperture is narrow "extending a little less than half around the body." The funnel is extensively merged in the head and its free portion is very short. The funnel-organ is of the usual shape, but its median part is far longer than the outer limbs as in *O. medoria* and *O. ochotensis*. The gill has $10\frac{1}{2}$–12 filaments in each demibranch. The hectocotylized arm is markedly shorter than its fellow. The ligula is 7% of the arm, and its groove is well defined and furnished with numerous laminae. The penis is "devoid of a diverticle," a very unusual feature. The vaginae are thick and short. The ovarial eggs measure 17 × 7 mm. and are therefore very large.

Fig. 82*a*.—*Paroctopus yendoi*. Outline of head and mantle. × ·8.

Maximum size.—290 mm. (Sasaki).

Variation.—Specimen No. 332987, kindly sent on loan from the United States National Museum, Washington, differs from the type in some important respects which are tabulated below.

1. *Profile*: ocular constrictions as in fig. 82*a*.
2. *Arms*: (i) formula, 1.3.4.2.: unequal in size.
   (ii) maximum size, 82%.
3. *Web*: (i) 25% of arms.
   (ii) formula: A = B.C.D. = E.
4. *Mantle-aperture*: B–C.
5. *Ligula*: 6% of the arm. Very narrow, the calamus basal.
6. *The Penis* is devoid of an appendix. The diverticle is a long one, and the organ is of the *Joubinia* type.

Remarks.—It is difficult to reconcile Sasaki's statement, that the penis is devoid of diverticle, with the fact that a long diverticle recalling

that of *Joubinia* is present in specimen No. 332987. Sasaki does not say how many examples he dissected. It is possible that he only examined one, in which the diverticle was atrophied. The diverticle in No. 332987 is well-formed and thick-walled. It contains no spermatophores and its size and shape are therefore not due to temporary enlargement of its cavity by the latter. If it is a permanent characteristic of the species it may be necessary to consider the relationship of *O.yendoi* to *Joubinia*. In the meantime the species seems more closely related to *hongkongensis* and *apollyon*, and is therefore included in the same genus as those species. Its large eggs (see p. 206), well-developed ligula and the general facies all remind one of those forms, though it is by no means a typical member of the genus.

Genus 9. **Hapalochlaena,** new genus.

Type of the genus.—Octopus lunulatus, Quoy & Gaimard.

Definition.—Octopodinae having the ink sac reservoir much reduced in size. The arms are short and the web is subequal and deep. The colour-pattern consists of (? iridescent) rings.

The identity of the two species placed in this genus and their mutual relationships constitute a very difficult problem. In 1832 Quoy and Gaimard described a very small Octopod from New Ireland as *O. lunulatus*. It was described as ovoid in body, slightly pointed at the extremity, with elevated suckers and lunulations of sky-blue with pale centre on a pale ground. Orbigny (1840), who evidently saw the type, amplified the description. According to that author the shape, which was apparently ovoid in the living state, had become (? by preservation) more or less spherical and had lost the apical point. The body was as wide as long. The more or less subequal arms were in the order 4.3.2.1., and about 65% of the total length. The web seems to have been rather low (about 22%). The animal was pale and covered with bluish circles, which stood up in relief from the skin, and contained a tubercle in the centre.

I have examined the type in the Musée d'Histoire Naturelle, Paris. It is undoubtedly a young specimen. The bluish rings are darkish within, *i.e.* not exactly placed directly on the pale ground, and the body is tuberculate. In other respects Orbigny's description is accurate.

In 1882 Brock described as *O. pictus* * an Australian form having very short arms and covered with masses of dark pigment, in the middle of which is a *dark* circle. The arms are banded by dark maculae on an ochreous ground.

I have examined the type (an adult) of this species and, though it has a certain general likeness in proportion and in web- and arm-length to the type specimen of *lunulatus*, its colour-rings are dark, not bluish. I have furthermore had access to a large number of specimens assigned to "*pictus*" and *lunulatus*, and among them there are (Brit. Mus.) a series obtained from North Australia, Moluccas, etc., short-armed, deep-webbed forms with larger rings on a homogeneous pale ground. In some of these the rings are brown, in some bluish. This form has a very deep web; it is more squat than the "*pictus*" of Brock, and its skin is gelatinous and

* This name was preoccupied (see p. 217), and Brock's species is now recognized as *O. maculosus*, Hoyle.

flabby. On first examining them I concluded that they were distinct from Brock's "*pictus*," and actually deserving of a distinct generic position. I considered that they represented the *lunulatus* of Quoy and Gaimard and were adults, the type specimen being immature. This view I wish to maintain, but it should be pointed out that Brock's *pictus* and the squat, deep-webbed form from the Molluccas are very much alike, and it is possible that the examination of a larger store of material might lead us to conclude that they are conspecific. There is a specimen in the Leipzig Museum and another in the British Museum from Batavia, with raised bluish rings on a dark maculated ground forming a "zébrure" on the arms, just as in Brock's "*pictus*" and in Hoyle's type of "*maculosus*." As the series in the British Museum contains forms otherwise identical in which the rings are bluish or dark brown, I must conclude that the iridescent bluish tinge is lost in certain conditions of preservation or is a variable character. In any case, it is now impossible to separate the maculate, dark-ringed form ("*pictus*") from that with bluish rings on a pale ground by the criterion of *colour* alone. The differences which for the time I am inclined to stress are those of (1) the radula, (2) the web, (3) size and disposition of the colour-rings.

The status of Quoy and Gaimard's *lunulatus* is nevertheless a little uncertain. A glance at the table on p. 54 will show how it differs from the larger form of which it is here regarded as a juvenile form. I think it is best treated as such; but we require a large series of intermediate growth-stages before we can speak with certainty as to its position.

As for the generic status of these two species I am very doubtful. The very short arms, the depth of the web in *O. lunulatus*, the novel colour-pattern and other peculiarities all suggest a different generic position from the rest of the Octopodinae. The hectocotylus in our specimens of this form has a definite calamus, but the ligula is undifferentiated, perhaps spoilt by the condition of preservation. This also seems to be the case in Brock's "*robustus*." The gills have a rather low number of filaments, and the radula shows special characteristics. The most striking feature in the internal anatomy is the reduction of the reservoir of the ink sac, which in three out of four specimens was exceedingly small. I consider that this is a permanent structural modification and not due to the emptying of the reservoir. The above-mentioned peculiarities justify the creation of a separate genus for *O. lunulatus*. At the same time it is by no means easy to decide whether *O.* "*pictus*" (= *maculosus*) should be included in that genus. This species does not exhibit the marked peculiarities of *lunulatus*, and seems more normal and like the other Octopodinae. On the other hand, it has a distinct tendency to have the ink sac reduced and shows a general likeness to *lunulatus*, so that it should perhaps be associated with that form. The relation between the two is thus very analogous to that between *O. macropus* and *M. maorum* (p. 174).

Hapalochlaena lunulata (Quoy & Gaimard).

(Plate IV, fig. 1; text-figs. 83–85.)

Octopus lunulatus, Quoy & Gaimard (1832, p. 86, Pl. 6, fig. 1), Orbigny (1840, p. 59, Pl. X, fig. 2; Pl. XXVI, figs. 5–7), Gray (1849, p. 11), Hutton (1880, p. 1), Tryon (1879, p. 121), (?) Brazier (1892, p. 6).

Type specimen.—In M.H.N., Paris. (? Holotype.)

Specimens seen.

(*a*) in Brit. Mus.

One (♀) from the Swan River. Two (♂♀) from Misol Id. One (♂) from Port Essington.

(*b*) In M.H.N., Paris.

One (♀) from N. Ireland. ("Type," 1829.)

Distribution.—New Ireland (Carteret Harbour) (Quoy and Gaimard);

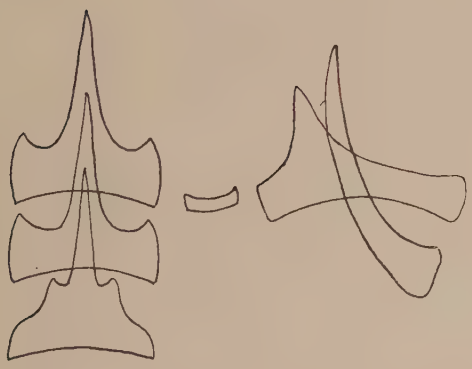


Fig. 83.—*Hapalochlaena lunulata.* Radula. (See p. 210.)

Fig. 84.—*Hapalochlaena lunulata.* Mandibles. × 5·7.

Misol I., Port Essington (Brit. Mus.); ? Torres Straits, Solomon Is. (Brazier). I am unable to ascertain which "Swan River" is meant, viz. that in West Australia or that in New South Wales. There is no record of the species in Hedley's New South Wales "List" (1920), so that it is likely to be the former locality. The Museum record is also tantalizing in that it does not specify in what part of the river the specimen was taken. Hutton (*l.c.*) rightly points out that Gray wrongly gives "New Zealand" as the locality. This was obviously a mistake for Quoy and Gaimard's "Nouvelle Irlande." Unfortunately Tryon and others perpetuated the error. I can find no Carteret Harbour in New Ireland. Possibly Carteret I. in the Solomon Islands is meant.

Description.—The skin is very soft and gelatinous in the three specimens in the British Museum. I think this may be due to bad preservation.

The mantle was evidently ovoid in the young example described by Quoy and Gaimard, when alive. In the preserved state the latter is

globular, as in the three adult specimens (Brit. Mus.). The width-index of the latter ranges from 93–70%, and the head is markedly narrower (73–57). The arms are mostly in the order 4.3.2.1. or 4.2.3.1. They tend to be subequal, but the fourth is usually longer than the rest. The longest arms are 69–74% of the total length. They are exceedingly fine-drawn at the tips. The suckers are deeply sunk in the gelatinous skin and are relatively small, their diameter rarely exceeding 8% of the mantle-length. There is no local enlargement of certain suckers in the male. The web has the following proportions: A, 32; B, 36; C, 34; D, 34; E, 33. At its maximum it reaches nearly half-way up the arms, a condition I can hardly reconcile with Orbigny's statement that it is very short " même à peine visible dans l'animal contracté " (p. 60). In the type it is much more shallow.

The pallial aperture is usually a little more than half closed (B.B–A). The septum is very deep, reaching backwards for about 27–28% of the

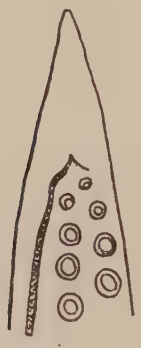


Fig. 85.—*Hapalochlaena lunulata.* Hectocotylus. × 5.

Fig. 86.—*Hapalochlaena lunulata.* Penis. × 3·2.

mantle-length, and, as far as I can ascertain, the communication between the two halves of the mantle-cavity is very much restricted by the growth of a sheet of connective tissue across the post-septal fenestra. The funnel is very short, its free portion being 34% of its total length. The funnel-organ is present in one out of our four specimens; it is small, delicate and W-shaped. There are nine inner and seven outer lamellae in each gill, and the inner demibranch is reduced at its base.

The alimentary system (including the large crop) is normal. The ink sac has a long slender duct, and its reservoir is conspicuously reduced in size. *The mandibles.* The rostral lamella of the upper mandible is degenerate, and the upper mandible is in general weakly chitinized. *The radula.* The rhachidian has a symmetrical seriation (A_2). There are two remarkable features, viz. the lowness of the rhachidian mesocone, the height of which is equal to the basal width, and the exceedingly ill-developed ectocone of the first lateral. The second lateral has an inner heel but no entocone. The rhachidian is rather too tall in fig. 83.

The generative organs :—

(1) *Male.* The internal organs do not call for comment. The sper-

matophores are multiple, rod-like and simple in shape. The penis has a free portion of some 2·5 mm. in length and a saccular appendix. The *hectocotylus* is remarkably simple in the single large male at my disposal. The ligula is entirely undifferentiated. The spermatic groove, on the other hand, is extremely well developed. It is very thick walled and is evidently highly glandular. It passes into a well-formed terminal space at the base of the calamus, but the latter is not present as a definite projection. The organ resembles that of *Macrochlaena*.

(2) *Female.* The oviducts are asymmetrical in the single large specimen in the collection. The right oviduct measures 4 (proximal part) and 15 (distal part) mm.; the left measures 1·5 and 12·5 mm. There is a distinct trace of a secondary oviducal gland.

The surface is smooth in one of the adults and heavily wrinkled in the other. One of the small specimens has traces of a kind of " malleolation," which may represent the tubercles mentioned by Orbigny. The colour is discussed on p. 207. The rings are thin and dark brown in two specimens, bluish and raised from the surface in the Port Essington example. There are 15–19 visible on the dorsum and none on the oral surface. In the larger specimens they measure 7–8 mm. in diameter.

Maximum size.—164 mm. (Brit. Mus.).

Remarks.—See pp. 207–8. Although this form exhibits none of the internal characteristics we usually associate with the deep-water Octopods, its general facies rather suggests a relationship to the latter. The relatively short arms and very deep web suggest *Bathypolypus*, while the minute suckers and closed mantle-aperture are likewise suggestive of the deep-water forms. It is possible that, as in *Pteroctopus tetracirrhus* (cf. Robson, 1926, p. 1356), some of the modifications similar to those exhibited by deep-sea forms may be developed in littoral forms which habitually burrow in mud. On the other hand, though the ink sac is reduced, the gill filaments are not markedly reduced in number. We are possibly dealing with a form like Grimpe's *Haptochlaena* (1922); but as that form was so imperfectly defined I do not care to associate our species therewith.

Hapalochlaena maculosa, Hoyle.

(Text-figs. 87–88.)

Octopus pictus, Brock (1882, p. 603, Pl. 37, fig. 3, preocc. Blainville, 1828, p. 8); *Octopus maculosus*, Hoyle (1883, p. 319, Pl. VI), Smith, (1884, p. 36, Pl. IV); *Octopus pictus* var. *fasciata*, Hoyle (1886, p. 94, Pl. VIII, fig. 3); *Octopus robustus*, Brock (1887, p. 317); *Octopus pictus*, Appellöf (1898, p. 568); Brazier (1892, p. 6); *Octopus pictus* var. *fasciata*, Goodrich, (1896, p. 19); *Octopus pictus*, Hoyle (1905, p. 979); *Polypus pictus* var. *fasciatus*, Wülker (1910, p. 6); *Polypus pictus fasciatus*, Berry (1912*b*, p. 393); *Octopus pictus*, Winckworth (1926, p. 327).

Holotype.—In University Museum, Göttingen.

Specimens seen.

(*a*) In Brit. Mus.

One (♀) from Port Jackson : 89.4.24.37. One (♂) from Port Phillip : 87.12.21.1. One (♂) from Redcliffe, Moreton Bay : 90.6.22.4. One (♀)

from Kangaroo Id., S. Australia. Two (?) from Port Jackson: 1907.7.22.10–11.

(*b*) In Univ. Mus. Göttingen.

One (♂) from ? Sydney. (Type.)

(*c*) In Senck. Inst., Frankfort a/M.

One from Ternate.

(*d*) In U.M., Leipzig.

One from Aburatsubo, Japan. One (♂) from Batavia.

(*e*) In Z.M., Berlin.

Nine from Amboina.

Distribution.—New South Wales [Port Jackson] (Brock (?), Hoyle, Smith, Brazier, Goodrich); Port Stephens (Brazier); South Australia (Brit. Mus.); Queensland (Brazier); Tasmania (*id.*); Aburatsubo, Japan (Wülker); Ceylon (Winckworth) (?); Indian Ocean (Mulaku Atoll), (Hoyle); Ternate (Appellöf).

This seems to be a littoral form, 15 fathoms being the maximum depth from which it has been obtained.

Description.—The body is usually rather oblong, the head being narrower than the body, except in the type. The arms are short (68–75% of the total length). If I am correct in placing Brock's "*robustus*" as a synonym, that form must rank as a markedly short-armed form. The order 3.2.4.1. or 3.4.2.1. is rather regular in its occurrence. The suckers are small, and are not specially enlarged in the male. The web is subequal (sector E being rather smaller than the rest) and is 20–31% of the arm-length, in Brock's "*robustus*" rising to nearly 50% in the middle. The surface, I think, is sculptured with low warts. In some specimens these are almost entirely absent or concentrated near the eyes, or else they may be very numerous. The colour-pattern consists of a yellowish-ochre ground covered with masses of dark pigment, which may be distributed as follows:—

(1) in masses of small flecks with dark inner rings;
(2) in broad maculae;
(3) in longitudinal or diagonal stripes;
(4) as a uniform dark tint.

The dark maculations are usually occupied by light rings or lines, sometimes of an iridescent bluish colour and often raised above the surface. In "*robustus*" the rings coalesce to form rosettes. The arms are usually marked by transverse dark patches in which bluish rings appear.

The mantle-aperture is rather narrow (B). The gill-filaments are singularly few, 6 in each demibranch. The funnel is free for over half its length. I have only seen the funnel-organ well preserved in one specimen. It is W-shaped and extremely long. The radula figured by Hoyle (1883, Pl. VI, fig. 4) agrees fairly closely with that of our specimen from Kangaroo Id. The rhachidian has an A_2 seriation. The first lateral has a rather wide base and prominent cusp. The cusp of the second lateral is low and practically marginal, there being no ectocone on this tooth. The third laterals are very slender and markedly incurved at the extremities. The ink sac in three examples is smaller on the whole than in (*e.g.*) *Octopus* (s.s.). However, the reduction is not so marked as in *H. lunulata*, and in one example it was but slight.

The hectocotylized arm is rather shorter than its fellow. The ligula is variable in length. It has a rather shallow median groove (apparently absent in "*robustus*"), and the calamus is situated almost half-way between the last sucker and the distal extremity. There is, however, a good deal of difference in detail between individuals (cf. fig. 87). This is also noted by Goodrich (*l.c.*, p. 19).

Maximum size.—114 mm. (B.M.).

Variation.—On the whole I believe that this is a fairly homogeneous species. The small, rather ovoid body, short arms in the order 3.2.4.1., small suckers, subequal web and yellowish body maculate with black or blackish brown are a fairly distinctive and constant assemblage of characters. The colour-pattern is, however, not very constant. (1) Brock's type is by no means a common form. The usual broad

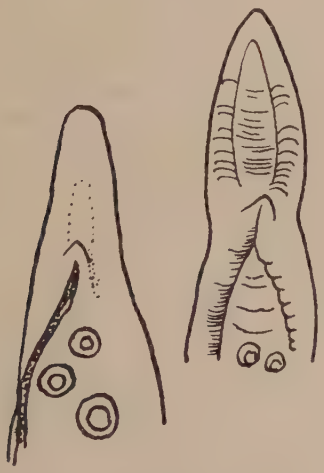


FIG. 87.—*Hapalochlaena maculosa.* Hectocotylus. (*a*) B.M., 90.6.22.4. (*b*) B.M., 87.12.21.1 × 9·5.

FIG. 88.—*Hapalochlaena maculosa.* Penis. B.M., 90.6.22.4. × 5.

maculation seems to be replaced by flecks which exhibit *black* rings inside them, a feature present in none of our specimens nor in Appellöf's Ternate specimens. Brock says that the patches on the arms are devoid of rings. (2) The fasciate pattern (Hoyle, Goodrich, Wülker) seems rather common. In this the pigment is assembled on the dorsum in longitudinal stripes. (3) Sometimes the main mass of pigment is uniformly distributed (Wülker, 1910, p. 6; Brit. Mus.).

Remarks.—Hoyle (*l.c.*) withdrew his *maculosus* in favour of Brock's *pictus* (with which it is obviously conspecific). Brock's name is, however, clearly a homonym of Blainville's *pictus* (1828, p. 8), and, although the status of the latter is ambiguous, must be rejected.

The *O. pictus* of Blainville was placed in the synonymy of *Philonexis catenulata* (= *Ocythöe tuberculata*) by Orbigny. I have not succeeded in tracing the type of Blainville's species. His description is very defective, but I think an *Ocythöe* is indicated by it.

Brock's species differs from *H. lunulatas* in the following respects:—

(1) The colour rings are smaller and are usually placed on aggregations of dark pigment, which may form maculae or stripes on mantle, web and arms.

(2) The web is usually more shallow.

(3) The radula has (*a*) a more prominent cusp on the first lateral, (*b*) a more regular A_2 rhachidian and (*c*) finely pointed third laterals which are broader at the base.

(4) The body and head tend to be narrower.

These differences are, however, not absolute, and individual specimens exhibit combinations of the characters of the two species; *e.g.* Brock's "*robustus*" has a very deep web (*lunulata*) combined with the maculate colour-pattern (*maculosa*).

INSUFFICIENTLY DIAGNOSED SPECIES.

1. *Octopus longipes*, Leach (1817*a*, p. 139). The description is quite inadequate, and might be applicable to several species.
2. *Octopus coerulescens*, Blainville (1826, p. 189); "Dorre" Id., ? Australia. Apparently described from Péron and Lesueur's notes. A small form 6 cm. long with arms 66%. The blue ground-colour and the fact that the suckers terminate in points are characteristic features. The form of the suckers, as Gray points out, would suggest that this form belongs to a different family.
3. *Octopus appendiculatus*, Blainville (*l.c.*, p. 185). This is a species from Indian Seas with a round body provided with a lozenge-shaped fleshy appendage on the back, very slender and extremely long arms and deep web (twice as long as the body and extending right up the arms), and three cirrhi over each eye. The species was founded on a description published by Kölreuter in 1761 and an extended account by de Montfort. The species is insufficiently described.
4. *Octopus variolatus*, Blainville (*l.c.*, p. 186). Described evidently from Péron's notes. It was obtained off Dorre Id., Dogs Bay, Australia. The description is very slight—"corps très grand; peau couverte de tubercules très serrés et très nombreux; appendices . . . extrêmement longs," etc. Assigned perhaps correctly by Péron to *O. rugosus*. See p. 128.
5. *Octopus pustulosus*, Blainville (*l.c.*, p. 186). From the same locality as the preceding. The skin is dense and wrinkled and of a greenish-brown colour. It differs from No. 4 only in size of arms and suckers. Péron states that it exhales a smell of musk. He referred it to *O. rugosus*; but it is possibly an *Eledone* ("ventouses plus rares"; odour of musk).
6. *Octopus frayedus*, Rafinesque (1814, p. 28); Sicily. "Anténopes égaux, égalant presque six fois la longueur du corps . . . extrémité sans suçoirs . . . dos rougeâtre." Possibly *O. macropus*, but very doubtful.
7. *Octopus didynamus*, Rafinesque (*l.c.*); Sicily. "Anténopes . . . inégaux, deux plus longs, égalant presque cinq fois la longueur du corps; dos brunâtre." If this is a Mediterranean form, it may be a variety of *macropus* with rather short arms.

8. *Octopus tetradynamus*, Rafinesque (*l.c.*); Sicily. "Anténopes inégaux, alternativement plus longs, égalant cinq fois la longueur de corps: dos grisâtre." Possibly *O. vulgaris*.*
9. *Octopus heteropus*, Rafinesque (*l.c.*); Sicily. "Anténopes . . . à peine plus longs du corpses inégaux: deux supérieurs les plus longs: dos rougeâtre." The last two characters suggest *O. macropus*. The arms are too short for an adult specimen of that species. "*Heteropodus*, Raf.," Blainville (*l.c.*, p. 190).
10. *Octopus ruber*, Rafinesque (*l.c.*); Sicily. "Anténopes égaux, environ le double du corps . . . corps entièrement rouge." Orbigny (1840, p. 40) believes that this is a form of *O. tuberculatus* (*rugosus*). Delle Chiaje referred it to *O. macropus*. Orbigny is more likely to be right on the very scanty evidence.
11. *Octopus pilosus*, Risso (1826, p. 4); Mediterranean. This form is enigmatic. It is described as "corpore . . . pilis ruffescentibus, fasiculatis [sic] supra ornato; pedibus brevissimis."
12. *Octopus unguiculatus*, Blainville (*l.c.*, p. 192, after de Montfort (*l.c.*, p. 99)); Chili. ? = *Onychoteuthis* sp. or some other Decapod.
13. *Octopus antiquorum*, Blainville (*l.c.*, p. 192); Mediterranean. ? = *Argonauta*.
14. *Octopus raricyathus*, Blainville (1819, p. 194), ? Amboina. ? = *Argonauta* sp.
15. *Octopus* "*P.* [*sc. O.*] *Cranchii*," Blainville (1826, p. 195); Gulf of Guinea. ? = *Argonauta* sp. Placed in *Ocythoë* by Leach (1817, p. 296, Pl. XII, figs. 1–6).
16. "*Octopus punctatus* (Say)," Blainville (*l.c.*, p. 195); ? loc. Perhaps *Argonauta* sp. Placed in *Ocythoë* by Say (1819, p. 107).
17. "*Octopus tuberculatus*, Rafin.," Blainville (*l.c.*, p. 196); Sicily. ? = *Argonauta* sp.
18. *Octopus moschatus*, Rafinesque (*l.c.*, p. 28, preocc., see No. 57); Sicily. "Anténopes égaux égalant quatre fois la longueur du corps, suçoirs opposés, corps blanchâtre." *
19. *Octopus albus*, Rafinesque (*l.c.*, p. 29); Sicily. *Nomen nudum* (no definition).
20. *Octopus niger*, Rafinesque (*l.c.*, p. 29); Sicily. *Nomen nudum* (no definition).
21. *Octopus maculatus*, Rafinesque (*l.c.*, p. 29); Sicily. *Nomen nudum* (no definition).
22. *Octopus colossus*, Gray (1849, p. 19). Listed as an "apocryphal species" by Gray. It is Montfort's "Poulpe Colossal" (1805, pp. 1, 256), which is unrecognizable.
23. *Octopus gigas* (Oken). Oken's *Sepia gigas* (1835, p. 345) is treated as an *Octopus* by Orbigny (*l.c.*, p. 358).
24. *Octopus brevipes*, Orbigny (1835, p. 22, t. I, figs. 1–3); "23°N., 35°W. de Paris." This is a very juvenile form, 17 mm. long, with the following characters:—Mantle ovoid, as long as wide and a little wider than the head. The head is large and the eyes prominent. The arms are subequal and only a little more than 33% of the total length. The web is short. The ground-colour is whitish and is covered everywhere with red chromatophores, which are larger

* Rafinesque describes the suckers as "opposés." In Nos. 6, 7, 9 and 10 they are "alternes."

and more numerous on the back. There is nothing distinctive save the very short arms, which are diminutive even for a juvenile Octopod.

25. *Octopus venustus* (Rang, 1837, p. 66, Pl. 93); Goree, W. Africa (Rang); Algiers (Aucapitaine in Tryon, 1879). This is again a very immature form, 2 cm. in total length. It has a long ovoid and transparent body, prominent eyes and short equal arms (50%). The colouring consists of a median dorsal golden-red patch, two rows of chromatophores down each arm corresponding to the suckers, and some transverse rows on the head. Hoyle (1909, p. 299) thinks it may be an *Eledonella*. "*O. venustus*, Rang," Robson (1925, p. 439), from Chagos Id., Indian Ocean, another immature form, is probably an error.
26. *Octopus peronii* (Orbigny, 1826, p. 144, *nomen nudum*). Mentioned by name as a *Sepia* by Lesueur (1821, p. 101, [*nomen nudum*]); "Baie des Chiens-Marins," Australia. There is nothing which enables me to identify the species. Orbigny (1840, p. 66) places it in the synonymy of *O. pustulosus*, Bl'v.
27. *Octopus carenae*, Vérany (1837, p. 92, Pl. II); Mediterranean. ? = *Ocythoë tuberculata*.
28. *Octopus Koellikeri*, Vérany (1847, p. 513, 1851, p. 33, Pl. XI); Mediterranean. ? = *Tremoctopus* sp.
29. *Octopus cocco*, Vérany (1851, p. 22, Pls. XII, XII bis); Mediterranean. = *Scaeurgus unicirrhus*.
30. *Octopus monterosatoi*, Fra Piero (1895, p. 268); Mediterranean. Transparent; arms, 1.3.2.4.: 1.3.4.2. Length of arms, 84%. Web very shallow (10%), decreasing from A to E. The web is said to be "molto sviluppata," but is only 10% of the arms by the measurements given. From all appearances this might be a form of *O. macropus* which has by some accident of preservation become gelatinous and semitransparent.
31. *Octopus coerulescentes*, Fra Piero (1895, p. 267); Mediterranean. Probably a colour-variety of *O. vulgaris*.
32. *Octopus catenulatus*, Vérany (1840, pl. fig. 9; 1851, p. 37, Pl. XIII); Mediterranean. ? = *Ocythöe tuberculata*.
33. *Octopus capensis*, Eydoux & Souleyet (1852, p. 11, Pl. I, figs. 6, 7); Cape of Good Hope. A very minute form, obviously immature. Total length, 12 mm.; arms, 41%; web deep (about 35%); mantle ovoid. Interocular index about 60%. Spotted with red chromatophores. It cannot be identified as the young of any known species.
34. *Octopus mollis*, Gould (1852, p. 479); Samoa. A young form presenting no special characteristic, except perhaps the delicate venation of the arms. Gould compares it rather inaptly with *O. indicus*: Appellöf (1898, p. 566) provisionally identifies some small forms from Ternate with this species, but it is quite impossible to decide if they are correctly named. Width index, 70%; head index, 63%; arms, 4.3.2.1.; arm-length, 71%. Web formula (?) A = B.C.D.E.; skin smooth; ground-colour ochreous (in spirit), closely covered with brown chromatophores with delicate "venations" on the arms.
35. *Octopus vérany*[*i*], Wagner (1829, p. 388); Mediterranean. The

presence of " orifices " on each side of the funnel indicate that it is probably an example of *Ocythöe tuberculata*.

36. *Octopus leucoderma*, Sangiovanni (1829, p. 317); Mediterranean. The description "Un seul ordre des ventouses sur chaque bras" indicates that this is an *Eledone*.
37. " *Octopus argonautae*, Blainville, 1826," Orbigny (1840, p. 358, ? in error). The reference in Blainville (1826) cannot be traced.
38. *Octopus atlanticus*, Orbigny (1835, p. 19), under " sous-genre *Philonexus* [sic]."
39. " *Octopus reticularis*, Petagua (1828)," Orbigny (1840, p. 87). ? = *Ocythöe*. Not traced.
40. *Octopus catenulatus*, Orbigny (1840, p. 358, not 1828, (*nomen nudum*)). ? = *Ocythöe*.
41. *Octopus eylais*, Orbigny (1835, p. 20). " Sous-genre *Philonexus*."
42. " *Octopus ferussaci*, delle Chiaje," Orbigny (1840, p. 358). ? = *Ocythöe*.
43. *Octopus hyalinus*, Rang (1837, Pl. 16). ? = *Tremoctopus*.
44. " *Octopus Kraken*, Montfort," Orbigny (1840, p. 358). Unidentifiable.
45. *Octopus mycrostoma*, Reynaud (1831, p. 23). ? = *Tremoctopus*.
46. *Octopus minimus*, Orbigny (1835, p. 23); Orbigny (*l.c.*) refers this to *Philonexus*; but later (1840, p. 358, as *O. mminimus* (!)) to *Argonauta hians*. ? = *Argonauta*.
47. *Octopus moschites*, Carus (1824, p. 319). = *Eledone*.
48. *Octopus quoyanus*, Orbigny (1835, p. 17). " Sous-genre *Philonexus*."
49. *Octopus semipalmatus*, Owen (1836, p. 112). ? = *Tremoctopus*.
50. *Octopus dubius*, Eydoux & Souleyet (1852, p. 15). ? = *Tremoctopus*.
51. *Octopus velifer*, Orbigny (1840, p. 91, not *id.*, (? 1830, plate only)). ? = *Tremoctopus*.
52. *Octopus velatus*, Rang (1837, p. 60). ? = *Tremoctopus*.
53. *Octopus ventricosus*, Grant (1827, p. 309). ? = *Eledone*.
54. *Octopus violaceus*, Orbigny (1840, p. 91, not *id.*, (? 1839, plate)). ? = *Tremoctopus*.
55. *Octopus pictus*, Blainville (1828, p. 8). " Corps ovale oblong, couvert de tubercles. Appendices courts, s'amincissant graduellement en pointe, garnis de suçoirs pédonculés." Orbigny (*l.c.*, p. 87) places this form in the synonymy of his *Philonexis tuberculatus*. We do not know if this opinion is correct. Blainville says, " nous ne connaissons cette espèce que d'après la courte déscription incomplète donnée par M. Risso." This description cannot be traced, and is probably a MS. record. Blainville thought that his *pictus* may have been the same as Risso's *tuberculatus*.
56. *Octopus gracilis*, Eydoux & Souleyet (1852, p. 13). ? = *Tremoctopus*.
57. *Octopus moschatus*, Lamarck (1798, p. 130). = *Eledone*.
58. *Octopus cirrhosus*, *id.* (*l.c.*). = *Eledone*.
59–63. " *O*[*ctopus*] *tritentaculatus*, *rufus*, *niger*, *cocco*, *violaceus*. Risso." Vérany (*l.c.*, p. 47, " espèces nominales ").
64. *Octopus aldrovandi*, delle Chiaje (1830, p. 57, Pl. 56, after de Montfort, 1801, p. 55). = *Eledone*.
65. *Octopus montevideo*, *ciliatus*, Rang (*l.c.*, pp. 62, 65). *Nomina nuda*.
66. " *Octopus pennanti*, [of whom ?] = *Moschites cirrosa*," Hoyle, 1909, p. 296.
67. " *Octopus antillarum*, ? Orb." Dall (1896, p. 27), ? in error.

Species of Uncertain Generic Position.

I include under this heading certain forms which may possibly be referable to the Bathypolypodinae.

1. **Octopus pricei** (Berry).

Polypus (sp.) young, Berry (1911*a*, p. 303); *Polypus pricei*, *id.* (1913, p. 73); ? *Octopus pricei*, Winckworth (1926, p. 326); ? not *Polypus pricei*, Massy (1916A, p. 209, Pl. XXIII, figs. 7–8).

Holotype.—In the Stanford University, California.

Distribution.—California. Santa Catalina Island; Monterey Bay (from stomach of *Onchorhynchus tschawytscha*). (Type.) ? Arabian Sea (Massy); ? Ceylon (Winckworth).

Description.—The animal's tissues are delicate. Its body is " elongate pyriform and obtusely pointed behind." There is a well-defined neck, and the head, which is rather narrower than the body, carries very large and protruding eyes. The arms are short (62%), subequal (at least in the type), thick at the base but rapidly tapering. The suckers are small, " little crowded [and] much elevated." The first 5–6 pairs seem to be uniserial. The web is equal, thin, hyaline and shallow (not more than 12% of the arms). The funnel is broad and 38–44% of the mantle-length. The funnel-organ was evidently found in a poor condition; but Berry states that " the indications are, however, that it is closely similar in outline to that of *P. californicus*" (*i.e.* V V-shaped). The hectocotylus, radula, etc., are not described by Berry. The colour is " very pale brownish buff everywhere except the region of the eyeball, the body and the head irregularly dotted with small brown chromatophores." Two rows of the latter up each arm.

Maximum size.—58 mm.

Remarks.—In 1916 Massy identified with this species three males from 544 fathoms in the Arabian Sea. She expressed no doubt as to the identification. Up to the time of writing I have not been able to see the type of Berry's species. On considering the full descriptions of Berry and Massy I am of the opinion that, as far as our information goes, these various forms are not closely allied. Whether they actually belong to the same genus is, I think, very improbable; and I am equally doubtful as to whether any of the larger specimens are mature. The rows of large chromatophores mentioned by Berry and Massy in their descriptions are suggestive of immaturity, as are the short arms. The web in Massy's specimen is, however, very deep, which is not necessarily a juvenile feature. Actually I think Massy's specimens may be mature. As for the various forms being conspecific the position is as follows. The general form and proportions, delicate structure, arm-length and relative proportion, colour and arrangement of chromatophores are more or less the same in Berry's and Massy's specimens. The web is far longer in Massy's specimens (which are not a great deal larger). She says " his (Berry's) specimens were taken from the stomach of a salmon and it seems reasonable to suppose that the fragile membrane . . . might easily suffer injury under such conditions." Massy's conjecture may be right,

but I would point out that (*a*) in Berry's Santa Catalina specimens the web is also "tenuous," and (*b*) if the web were digested, it is reasonable to expect that the surface tissues would have been also damaged in the Monterey example. But Berry does not mention this. The funnel-organ in the Arabian specimens is very characteristic, probably the most remarkable in all the Octopoda. In Berry's specimen this organ could not be accurately described, but it was said to be "closely similar in outline to that of *Polypus californicus*." That organ is composed of a double V, and in Massy's specimen it is in four subcircular pads. This constitutes a marked difference. On the other hand, the type of *O. pricei* has a very singular feature, viz. the first six pairs of suckers are practically uniserial. This feature is not noted by Massy in her specimen. I think that had this arrangement been present she would have commented on it. I have treated the "delicate" structure as a common feature; but it must be pointed out that, whereas Berry only calls his species delicate and semi-gelatinous (1911), Massy's specimen is "fragile and transparent." It thus becomes apparent that the Arabian and Californian examples by no means agree in all their features, and are probably markedly different in some respects. It therefore seems to me to be highly undesirable to treat them as conspecific. I think that *Octopus pricei* may be a member of the *O. californicus* group, while Massy's Arabian specimens may not be referable to the Octopodinae at all. Although I believe Massy's form is referable to a distinct genus, I do not consider it advisable to discuss its position until more is known as to its ink sac, radula, etc. (see p. 41).

2. **Octopus hoylei** (Berry).

Polypus hoylei, Berry (1909, pp. 407, 408, text-fig. 1), *id.* (1914*a*, p. 296, Pls. XLVII, XLVIII and LV); ? *Polypus hoylei*, Massy (1916A, p. 207).

Holotype.—U.S.N.M., Washington.

Distribution.—Hawaiian Islands in 257–460 fathoms, (of var. *annae*, Persian Gulf, Arabian Sea and S. of Ceylon, 25–130 fathoms).

Description (of the type specimen).—The body is saccular and rounded, about as broad as it is long. The head is broad and the eyes are prominent. In Berry's figure the head is shown as wider than the body; but this does not appear in the table of measurements (1914, p. 298). There is a moderate "neck." The arms are short, stout and rapidly tapered. They are probably subequal in length, though there is some marked difference in two of Berry's specimens. They are 70–73% of the total length. The suckers are said by Berry to be "moderately large"; but from the dimensions given I would rank them as small. There is no special enlargement of the suckers in the male. The web is deep and probably equal all round, though it is somewhat shallower ventrally; Berry says that it is one-third to one-half of the arms' length in depth. A striking feature is the very wide brachial membrane upon each arm. The pallial aperture is very narrow and is largely confined to the base of the funnel. The latter is short and broad and largely involved in the tissues of the head, though its extremity is free. The tip reaches a little less than halfway to the margin of the web. The funnel-organ consists of two V-shaped pads with narrow limbs and acute basal angle and extremities. The

hectocotylized arm is markedly shorter than its fellow of the left-hand side. The ligula in Berry's larger specimen is 5·6% of the arm, in the smaller 2·6%. It is " bluntly conical," and well excavated; the laminae copulatoriae are, however, weakly and obscurely developed. The calamus is acutely conical and its groove is deep. The colour is brownish-red. There is no definite pattern, but dorsally the minute chromatophores are distributed in " veins or obscure cloudings " which give the appearance of a pale reticulation. The integument is semigelatinous, and the surface is finely and regularly papillose. There are two prominent papillae over each eye.

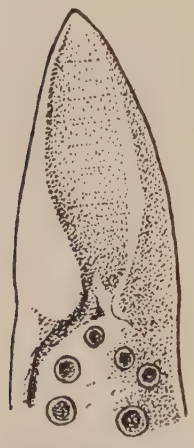


Fig. 89.—*Octopus hoylei*, var. *annae*. (Ind. Mus.) Hectocotylus. × 5·5.

Maximum size.—233 mm.

Remarks.—This deep-water form was compared by Berry with *Bathypolypus sponsalis*, and it certainly has the general facies of a Bathypolypodine. In 1916 Massy described four specimens (3♂, 1♀) from the Persian Gulf, Arabian Sea, and S. of Ceylon, which she referred to this species. The specimens came from moderate depths (25–130 fathoms). I have had the opportunity of examining Miss Massy's specimens, and, although I fully agree that there is a certain general similarity, I believe that the differences require recognition. At the same time my opinion is qualified by the fact that I have not seen any of Berry's *O. hoylei*. It is thus impossible to say if the reduced ink sac seen in Massy's specimens is found in the type or if the latter exhibits the general Bathypolypodine facies so strikingly seen in the Indian forms. I am strongly of the opinion that Massy's specimen represents a distinct genus on account of (*a*) the reduced ink sac, (*b*) the hectocotylus and (*c*) the funnel-organ, but until more information as to the type is available it would be premature to create a new genus for it.

Octopus hoylei var. **annae**, n. var.

(Text-fig. 89.)

" *Polypus hoylei*, Berry," Massy (1916A, p. 207).

Holotype.—In the Indian Museum, Calcutta (M $\frac{8125}{1}$ ♂).

Specimens seen.—One (♂) from the Persian Gulf. Two (♂) from the Arabian Sea. One (♀) from S. of Ceylon, in 25–130 fathoms.

Distribution.—As above.

Description.—The consistency of the tissues, the shape of the body, the general character of sculpture and colour, the size of the arms and suckers and the character of the funnel and funnel-organ all resemble those of Berry's species. The eyes are far less prominent than Berry indicates in his figure. The mantle-aperture is rather wider. The web is 38–47% of the arms. Berry states that in *O. hoylei* it is from one-third to one-half

of the arms. His figures (p. 298) for the first sector (which, as the web is equal (save in E), may represent the average depth) are 19–40%. Berry does not allude to the peculiar grouping of the chromatophores in star-like masses round each tubercle noted by Massy. The hectocotylus differs in one marked respect. The calamus is very minute, and the base of the heavily inrolled sides are expanded and cover it over. The organ is otherwise like that of *O. hoylei*, though it is markedly longer (9·6–12% of the arm), a difference which cannot be attributed to age, as Massy's specimens average smaller. The ink sac shows marked reduction in size. It is $\frac{1}{8}$–$\frac{1}{14}$ of the mantle in area, the normal size being $\frac{1}{4}$. The radula is that of a normal Octopodine. The rhachidian has an A_3 seriation, the second lateral is devoid of an ectocone and heel, and the marginals are degenerate. There are about 10 filaments in each demibranch; but the inner demibranch has undergone a remarkable amount of reduction.

Maximum size.—(?) 148 mm.

Remarks.—See above.

Postscript.—From a drawing subsequently received from Dr. Paul Bartsch I am able to state that the ink-sac in the type of *O. hoylei* is reduced and that in the type and var. *annae* the duct is long and coiled.

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"*Sepia octopodia*" (? syntype). Uppsala Museum.

FIG. 1.—*Octopus berenice* (holotype). × 1.

FIG. 2.—*Octopus areolatus*, var. *ovulum*. × 1.

FIG. 3.—*Octopus rugosus*, eggs. × 1.

FIG. 4.—*Octopus teuthoides* (holotype). × 2.

FIG. 1.—*Octopus ocellatus* (holotype). × 1.

FIG. 2.—*Octopus hardwickei* (syntype). × 1.

FIG. 1.—*Hapalochlaena lunulata*. × 1.

FIG. 2.—*Octopus medoria* (holotype). × 1.

PLATE IV

FIG. 1.—*Octopus aegina* (syntype). × ·8.

FIG. 2.—*Octopus cephea* (holotype). × ·4.

PLATE V

PLATE VI

Fig. 1.—*Octopus joubini* (holotype). × 2. Fig. 2.—*Octopus taprobanensis* (holotype). × 2.

Fig. 3.—*Enteroctopus* sp. × 2·5.

FIG. 1.—*Octopus areolatus* (syntype; see p. 117). Leiden Museum.

FIG. 2.—*Octopus ocellatus* (syntype of *Octopus areolatus*, Orbigny). Leiden Museum.

PLATE VII

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